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TRACK ELEVATION IN CHICAGO will have an important extension under a recent ordinance covering the several main tracks, connecting tracks and yard tracks along the line of 16th St., between Western Ave. and Canal St., and from 12th St. to 39th St. The Chicago, Burlington & Quincy R. R., Chicago & Northwestern Ry. and Chicago Terminal Transfer Ry. will elevate three miles of double track between Western Ave. and Canal St. (to be completed before 1909); the Chicago Junction Ry. and Pittsburg, Cincinnati, Chicago & St. Louis Ry. will elevate two miles of double track between 12th and 39th Sts. (to be completed before 1907). There will be in all about 5½ miles of main track (double track) and probably 25 miles of yard track involved in the change, eliminating 36 grade crossings and substituting 30 subways for these crossings. Work is expected to be commenced very soon. A special feature of this part of the track elevation system is that it will involve the removal of four of the steel viaducts built under the old policy of leaving the tracks at grade and carrying important streets over them by viaducts.

THE SAN FRANCISCO FREIGHT TERMINAL of the Atchison, Topeka & Santa Fe Ry. will be built on made land, covering an area of about 50 acres of submerged land and low-lying flats. This area is known as the China Basin, and is now being filled in. A bulkhead of piling, backed with broken rock, has been built and the work of filling is in progress. To obtain material for filling, the railway company bought the property on a hill about a mile distant, and this hill is now being excavated and destroyed. The rock is broken up by blasting, and loaded by three Bucyrus steam shovels into six trains of Goodwin 40-ton steel dump cars, which are hauled out on temporary trestles to the dumping points. When the bank rises above the trestle a spreader car levels it off. The steam shovels work on three benches or terraces, 15 ft. apart vertically. The contract for this work was let to R. B. Lantry & Sons, of Strong City, Kan., and the work is done under the direction of Mr. R. B. Burns, M. Am. Soc. C. E., of Los Angeles, Cal., Chief Engineer of the Western Lines of the Atchison system. It is to be completed in about two years.

THE MERGING OF THE SEWERAGE AND DRAINage boards of New Orleans has been authorized by the Legislature of Louisiana. This action, however, increases the membership of this board in a manner not contemplated by the citizens or provided for in the Constitution of the State. The present Drainage Commission had acquitted itself so well in the drainage of the city of New Orleans and had so far secured the confidence of the taxpayers that when it was determined to expend $12,000,000 or more upon sewerage and a better water supply, it was expressly stipulated by these property holders that the handling of this large sum of money should be entrusted to the Drainage Commission and seven property owners appointed by the Mayor from each municipal district. This request was engrafted into the Constitution of the State, after its adoption as a constitutional amendment by the public election of April 17, 1900. Under the Haggerty act, first referred to, this board would be increased to 21 members, or nearly doubled, and the power of the old Drainage Commission would be correspondingly curtained. In other words, the safeguard demanded by the people would be destroyed. The New Orleans Progressive Union, representing the taxpayers, has requested Gov. Heard to veto the bill.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a collision between a freight train and a shifting engine on the Allegheny Valley branch of the Pennsylvania R. R. at Kiskiminetas Junction, Pa., on July 1. Two men were killed. The accident is said to have been due to disregard of signals by the freight crew.——On June 29, an excursion train on the Colorado Midland Ry. was derailed by a broken rail near Cascade, Colo. One man was killed outright and many others seriously injured.

A BAD TROLLEY CAR COLLISION occurred on June 28 on the line of the Marlborough Street Railway, between Marlborough and Hudson, Mass. The two cars were both heavily loaded, and at the time of the wreck were going at high speed. They came together at the foot of a steep grade, where a curve hid them from view of each other. One of the cars was completely telescoped; its motorman was killed, and a large number of passengers seriously injured.

AN ELECTRIC TRAIN CAUGHT FIRE on the Third Ave. line of the Manhattan Elevated R. R. on June 30 and three of the cars were destroyed. The train was unoccupied and was standing on the middle track when the fire broke out, about 3 a. m. Two alarms were rung, but the fire continued for an hour, stopping all traffic on both northbound and southbound tracks.

A CITY MAY CONDEMN and appropriate the property of a water company without paying for the franchise and good will, according to a Massachusetts statute. By a United States Court decision on June 23, in the case of **the Gloucester Water Supply vs. the City of Gloucester** this statute is held not to conflict with the Federal Constitution. The company in its suit claimed that the act was void because the company's franchise, good will and earning capacity, alleged to be worth $900,000, were excluded by the statute as elements of the value or price to be paid by the city, and that it, therefore, unwarrantably authorized a taking without due process of law. The demurrer was based upon the ground that there was shown to have been no taking in violation of the Federal Constitution, and that the decision of the State Supreme Court was conclusive. Judge Colt, of the U. S. Circuit Court, sustained the demurrer.

THE INSURANCE ENGINEERING EXPERIMENT Station, at Boston, planned by Mr. Edward Atkinson and referred to editorially in our issue of May 1, is already an accomplished fact. Over 160 firms and companies have joined in subscribing the necessary funds on the basis proposed by Mr. Atkinson (one cent for each hundred dollars of insurance carried). Prof. Chas. L. Norton, of the Massachusetts Institute of Technology, is in charge of the work and Mr. Joseph P. Gray is Consulting Engineer. Tests have already been made on fireproof partitions, and others are shortly to be made on cements, mortars and concretes, with especial reference to their influence on the corrosion of iron and steel embedded in them. The station is to be conducted under the general direction of the Massachusetts Institute of Technology, which has arranged to provide a course of instruction in insurance engineering.

THE PRODUCTION OF HYDRAULIC CEMENT in the United States during the year ending June 30, 1901, according to a bulletin just issued by the U. S. Geological Survey, reached the enormous total of 20,068,737 barrels. Of this total 12,711,225 barrels were Portland cement, 7,084,823 barrels were natural cement and 272,689 barrels were slag cement. The corresponding figures for the preceding twelve months were: Portland cement, 8,482,020 barrels; natural cement, 8,383,000 barrels, and slag cement, 365,641 barrels. It will be seen that during the year ending June 30, 1900, the production of Portland cement increased almost 50%, while the production of both natural and slag cements decreased. Domestic cements now supply over 90% of the total consumption of the United States.

IRON ORE PRODUCTION in the United States in 1901, says Mr. John Birkinbine, in Mineral Resources of the United States—now in press, amounted to 28,887,479 long tons, a gain of 1,334,318 tons over 1900. The total value of the ore mined in 1901 was $49,256,245, or a mean value of $1.71 per ton. In 1901 the red hematite mines contributed 83.10% of the total for the United States, with Minnesota the largest producer of this ore, and Michigan and Alabama following that state. The brown hematite mined amounted to 10.44% of the total output. The Lake Superior region produced 21,445,903 long tons in 1901, its maximum output. In the year 104 iron-ore operations each produced over 50,000 tons of ore. On Dec. 31, 1901, the total stock of iron ore on hand at the mines was reported at 4,239,823 long tons, an increase of 14% over the 1900 total. The total imports of iron ore for 1901 were 966,950 long tons, valued at $1,659,273, or $1.72 per ton; this is an increase of 7.7% over the imports of 1900. Of this import 552,248 tons came from the Cuban iron-ore deposits. During the year only 64,703 tons of ore were exported, nearly all going to Canadian blast furnaces.

VANADIUM STEEL is said to have been introduced in France by an American engineer, A. B. Frenzel, of Telluride, Colo. Considerable deposits of vanadium ores have been found in San Miguel and Montrose counties, in Colorado, and recent researches have shown that a small percentage of vanadium will increase the tensile strength of steel more than 100%. It is stated that the Creusot works of Schneider & Co. are experimenting with the new material.

THE BOWERS HYDRAULIC DREDGE PATENTS have been brought before the Senate Committee on Patents, with a bill to extend their life for a period of 17 years. A "Sun" dispatch of June 25 stated that the committee had voted 3 to 1 to report the bill favorably. The extension was opposed by the Commissioner of Patents, the Chief of Engineers and the Attorney-General. Senator Platt, of Connecticut, is to present a minority report against the bill.

A MONEY PRIZE SYSTEM FOR SEWER and street repair and connection gangs has been instituted by Commissioner of Public Works Redfield, of New York. The work is to be done between now and Oct. 1, and of the $250 appropriated for prizes, $150 is to be awarded in the Bureau of Highways and $100 in the Bureau of Sewers. Certificates of merit will also be issued to the men winning prizes, and a similar certificate, without money, is to be given to each member of the gang making the second best record in repairs or connections.

PRIZES FOR PRESSURE ANEMOMETERS, of 5,000, 3,000 and 2,000 marks, or about $1,250, $750 and $500, are offered by the German government. All designs must be submitted by April 15, 1903, to the Deutsche Seewarte, Hamburg, Germany, and the full program of requirements for competition can be obtained gratuitously from the Geheime Registratur D., Ministry of Public Works. All nations are invited to compete. A translation of the requirements and instructions will be found in the "Monthly Weather Review" for March, 1902 (price, 20 cts.), U. S. Weather Bureau, Washington, D. C.

THE PHILIPPINE TRANSPORTATION & CONSTRUCtion Co. some time ago bought the 19 steel canal boats of the late Cleveland Steel Canal Boat Co., each boat having a capacity of 400 to 450 tons. Four of these boats were carried to Hongkong on the tramp steamer "Melbourne" and two on the "Poplar Branch." The 13 other boats were cut into sections and stored in the holds of the ships. The four steam canal boats will each tow a barge from Hongkong to Manila, and the others will be towed by steamers regularly engaged in the Hongkong-Manila trade. These boats will be used in the Philippines for lightering vessels at Manila and other points, supplanting the 15-ton "cascoes" now employed for this purpose.

STEEL RAILS: THE RELATIONS BETWEEN STRUCTURE AND DURABILITY.*

By Robert Job.†

An investigation was begun some time ago at the Test Department of the Philadelphia & Reading Ry. to determine qualities in steel rails which resulted in fractures or in relatively rapid wear in service, and to work out the means necessary to reduce these to a minimum.

In order to gain information, arrangements were made to have forwarded to us a section of each rail which fractured in track or which was removed owing to undue rate of wear, together with detailed data regarding it. Such examination and tests as were necessary to establish clearly the cause of failure were then made. A considerable number of rails which gave good results in service have also been tested in the hope of finding fundamental characteristics which might account for the durability or the failure, as the case might be. Also, in our regular rail inspections at the mills, sections representing various methods of manufacture have been taken, and particular attention has been given to investigation of differences between rails which failed under the drop-test and those which passed it successfully.

We believed then, as we do now, that proper chemical composition is one of the essentials in obtaining the greatest durability in steel rails, but our work had confirmed that of others, which will be referred to below, in proving that physical character and structure have at least an equal influence upon the final outcome. Accordingly, we have not limited ourselves to determining chemical composition, but have tried in each case to ascertain the definite cause of the weakness, whether chemical or physical.

Up to the present time about 200 defective rails have been examined. In some cases complete chemical analyses have been made; in others the loose, coarse-grained fracture or other physical character—such as piping—showed the cause at a glance, and in still others a rather elaborate investigation was necessary to prove the matter to a certainty.

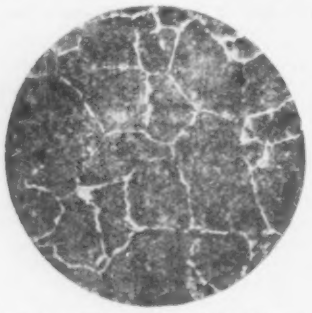


Fig. 1. Section Magnified 50 Diameters from Center of Head. Coarse Open Grain which Wears Rapidly in Service.

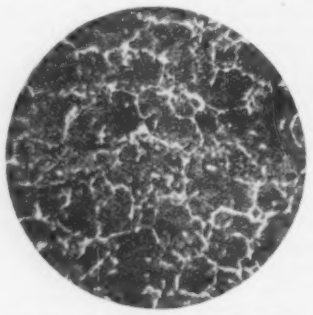


Fig. 3. Section Magnified 50 Diameters. Finer Granular Form which Gives Much Better Service than Fig. 1.

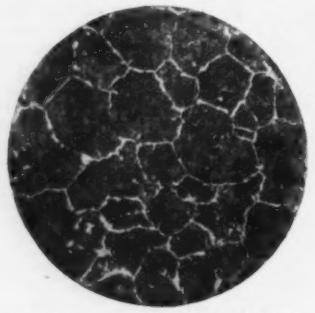


Fig. 5. Section Magnified 50 diameters from Center of Head. Rail Held Before Last Two Passes.

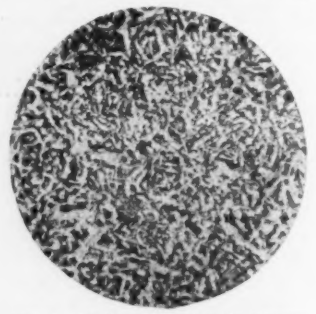


Fig. 6. Section Magnified 50 Diameters from Center of Head. Very Durable and Slow Wearing Rail. Thirty-four Years of Hard Service.

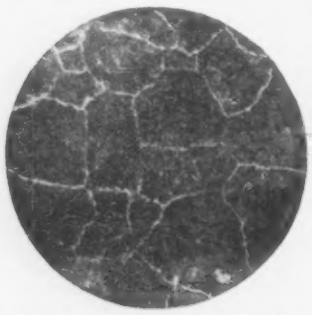


Fig. 8. Magnified 50 Diameters. Rapid Wearing Rail; Stood Drop Test.

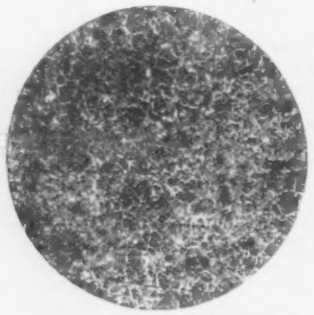


Fig. 10. Section Magnified 50 Diameters from Center of Head. Fig. 8 Re-heated.

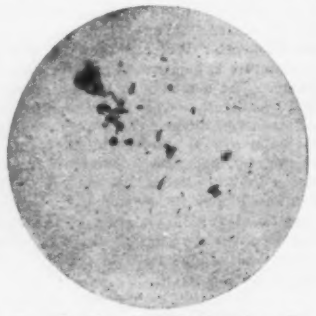


Fig. 13. Magnified 50 Diameters. Oxide spots in Figs. 11 and 12, Preventing Welding.

In a general way, the results of analysis in this investigation have merely confirmed the previous opinion, and have proved beyond question that specifying chemical composition alone ensures neither a durable rail nor often a bad rail. We found, however, from the start a marked difference in the structures, and note the following general characteristics in the rails which gave defective service:

(a) Coarse regular granular structure, Figs. 1 and 8 (magnified 50 diameters).

(b) Excess of foreign matter, such as oxides, slag and enclosed gas, Fig. 2 (reduced one-half).

Either characteristic resulted in relatively poor service.

On the other hand, in rails of the same general composition giving satisfactory service, we have found (c) a generally fine, interlocking, broken up, granular form, with

(d) Relative freedom from foreign matter and gas. Fig. 3, which will be referred to again, represents a coarse example of this finer structure, and Fig. 4 shows a characteristic structure of the head (reduced 54%), showing freedom from foreign matter.

Upon comparing the above results with those obtained in our mill inspections we found complete accordance, for the rails of the character a-b proved exceedingly fragile under the drop-test of 2,000 lbs. falling 20 ft. A section of rail, Fig. 2, from center of head, gave an elongation of only 2% in a 2-in. section, with tensile strength of 118,000 lbs. per sq. in. The analysis of these rails varied from: Carbon, .55 to .63%; phosphorus, .075 to .104%; manganese, .75 to 1.20%, and sulphur, .034 to .07%.

In contrast to this, rails when of the structure c-d, with the above composition, showed a marked toughness under the drop-test, and rail Fig. 4 stood 14 blows of the drop without fracture, turning after the first and third blows, and successive odd numbers. The composition was: Carbon, .644%; manganese, 1.09%; phosphorus, 0.81%; sulphur, .076%; and a test piece from a similar rail center of head, gave an elongation of 13% in 2 ins., with tensile strength of 132,000 lbs. per sq. in.

These marked differences were not at all unexpected, for they simply confirm the work of others. Mr. J. E. Stead, for instance, says:* "It is clear that the junctions (of the grains) are a safeguard, and the more junctions there are, the more reliable will the steel be." And again,† "it would seem to follow, then, that the smaller and finer the grain, the safer the structure. This coincides with the researches of Brinell, Sauveur and others.

Next, in order to find out how these results tallied with those of practical track service, we made a comparison upon a lot of about 50 rails which fractured in track, each having had a life of less than five years. They came from different points upon our lines, and had approximately the composition stated above. A number of different mills were represented, but all of the rails could be grouped under the head of "coarse-grained," or of "finer grain," and upon figuring the fractures in each class to a basis of equal tonnage during the five years, we found an average of fifteen fractures of the coarse-grained material to one fracture of the relatively finer-grained, and in each case of fracture of the latter, we found that the weakness was due to pipes in the steel—defective cropping. This comparison, of course, applies strictly only to actual fracture, but it is well known that the same conditions which here have produced fracture also contribute to rapid wear in service.

Turning now to the influence of mill methods upon the size of grain, during the past ten years marked progress has been made in knowledge regarding the metallurgy of steel, and thanks to the work of efficient investigators, the general relations between structure of steel and its physical properties are so well proven that cause and effect in many conditions of mill practice have become matters of definite certainty. Stopping thorough working of the steel while materially above the recalescent point and allowing to cool slowly, can result only in coarse granular structure, and such structure, other things being the same, has been proved by Professor Sauveur, Professor Martens, Mr. C. H. Ridsdale, Mr. R. G. Morse, Dr. Sargent, and others, to lower elongation and reduction of area, and to lessen the general toughness of the steel.

It will thus be seen that the unsatisfactory results which our service tests show with this coarse granular structure are merely the natural accompaniments of such character, and the entire investigation proves clearly the immense practical advantage in the betterment of quality which is being derived from the reasearches of metallurgists and metallographists, especially during the past decade.

The mills have not been slow to recognize the need of fine-grained structure in the heavier sections, and during recent years great efforts have been made to effect the change, and much progress has followed. At first, attention was directed merely to the finishing temperature; that is, the temperature at which the rail came through the last pass, without particular regard to the initial temperature of the ingot or bloom. In fact, high initial temperatures tended to prevail out of deference to the rolls, especially where these were light, or where the power was limited under such conditions it became necessary to hold the rails before running through the last passes, in order to finish at the desired temperature. The result of this procedure, as pointed out by Mr. S. S. Martin recently,* was to produce a fine granular form to the depth to which the working of the steel extended during these last passes, or to a depth of from ⅛ to ¼-in. below the surface of the head.

Our own studies had proved the correctness of this statement, and further showed that the size of grain at center of head was but little affected by such treatment, as shown in Fig. 5 (50 diameters). A surface toughening resulted, which should be of only temporary benefit, and could hardly from its nature cause any very decided increase in durability in service. The character needed is not a fine-and-coarse irregular structure, but one fairly fine even at the center of head, and practically amorphous at the surface; just such a structure, in fact, as we find in the rails of lighter sections rolled before the heavier sections came into use. Fig. 6 (magnified 50 diameters) represents the structure at center of head of a 67-lb. rail which was rolled and laid in 1864, and which withstood 34 years' heavy traffic, and since then has been in use in side track. The analysis is:

Carbon	.33%
Phosphorus	.039%
Manganese	.390%
Sulphur	.030%
Silicon	.070%

Fig. 7 (reduced 64%) represents the appearance of this rail in 1898, etched, and shows that it had evidently been greatly worn from its original section, and contained a pipe in the web. The metal, however, has not "flowed over" upon the side of head, although the steel is comparatively soft. In explanation, however, it is to be noted that the head is almost free from foreign matter, and that the structure even at center of head is exceedingly fine.

"Flowing over" has been found by us to be practically independent of the composition, and caused generally by unwelded seams due to presence of foreign matter and gas in the steel. In 1890 Dr. C. B. Dudley stated† that his studies of such rails "would seem to indicate that disintegration or crushing of steel is largely a resultant of lack of soundness in the ingot, and is more mechanical than chemical, except in so far as chemistry may be responsible for the soundness of the ingot." In some cases, however, we have found almost complete freedom from unsoundness, but in each instance a coarse granular structure was present. Dr. P. H. Dudley also states:‡ "The mineral aggregates are large and friable, and the surface of the rail breaks down more than 1-32-in. in

*Slightly condensed from a paper read at a joint session of the American Institute of Mining Engineers and the Mining and Metallurgical Section of the Franklin Institute, Wednesday, May 14, 1902.

†Chemist, Philadelphia & Reading Ry. Co., Reading, Pa.

*Journal Iron and Steel Inst., 1898, No. 1, p. 178.
†Journal Iron and Steel Inst., 1898, No. 1, p. 185.

*Iron Age, Dec. 26, 1901.
†Trans. A. I. M. E., 1890, xix, p. 893.
‡Trans. A. I. M. E., 1893, xxiii, p. 650.

epth, readily flowing under wheel pressures." Thus, it eems clearly established that such condition may arise rom marked weakness due to any cause, whether unoundness of the metal; weak, coarse structure, or even uch composition or form that the rail is unable to suport the load and becomes flattened.

In the case of the 67-lb. rail, Figs. 6 and 7, which gave xcellent service, the composition is exceptionally free rom defects. It is, however, a matter of common expeience everywhere that the composition of these old rails f light sections is exceedingly irregular. As Captain lobert W. Hunt expressed it last year before the Ameri-an Institute of Mining Engineers,* "they were high in arbon and low in carbon; high in manganese and low n that element; high in phosphorus and higher in phosphorus; but they all gave good service." One such rail taken from our tracks contained .169% phosphorus with .44% carbon, but still had given long service. The one characteristic common to all of these rails is that of fine

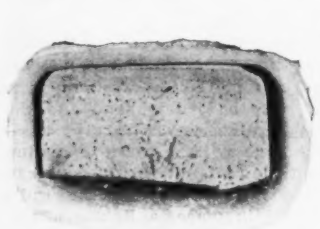


Fig. 2. (Reduced 50%.) Foreign Matter which Causes Brittleness.

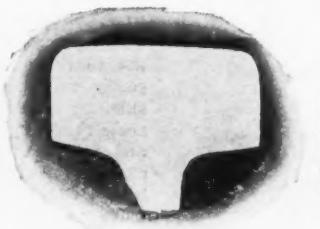


Fig. 4. (Reduced 54%.) Freedom from Foreign Matter.

Fig. 9. (Reduced 50%.) Foreign Matter in Fig. 8.

granular structure; in fact, it was necessitated by the conditions under which they were rolled, for the steel was thoroughly worked well down toward the critical point.

In order to note the exact influence of structure upon quality we took at random from a heat which passed the drop-test a rail having the following composition:

Carbon	.56%
Phosphorus	.102%
Manganese	1.08%
Sulphur	.056%
Silicon	.147%

turned down a section at center of head and obtained the following results:

Tensile strength	128,400 lbs. per sq. in.
Elongation in 2 ins.	8½%
Reduction of area	3½%

The structure (magnified 50 diameters) at center of head is shown in Fig. 8, and the etched head (reduced one-half) in Fig. 9. The former is very coarse, but the latter is tolerably free from foreign matter.

An adjoining portion of the same rail was then reheated to a cherry red, and let cool at once in the air. A test section was then turned from the center of head having

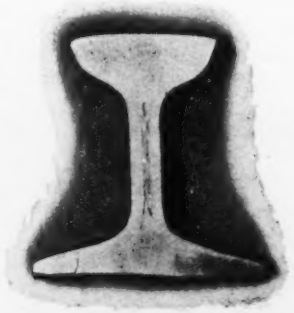


Fig. 7. (Reduced 64%.) Homogeneous Head. Rail of which Section is shown in Fig. 6, after Thirty-four Years' Service.

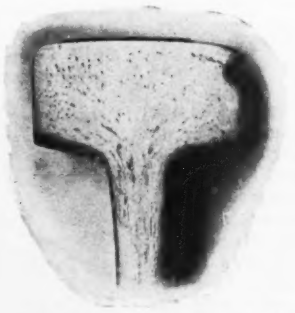


Fig. 11. (Reduced 52%.) Section of Rail Mashed Down in Track after Six Months' Wear.

a structure (magnified 50 diameters) represented in Fig. 10, and gave the following results:

Tensile strength	129,500 lbs. per sq. in.
Elongation in 2 ins.	12%
Reduction of area	10.1%

It is thus seen that the change shown in the structure has caused an increase of strength, an increase of nearly 50%, in elongation, and an increase of nearly threefold in reduction of area, fully accounting for the marked difference observed in service between the coarser and the finer structures, respectively. As Mr. William R. Webster stated at the Paris Congress of the International Association for Testing Materials, in 1900: "The matter of vital importance is to work steel in such manner that it is not put in service with this coarse grain."

In the foregoing we have seen that coarse granular structure seriously weakens steel, and that brittleness under the drop-test is found when in addition the metal is "burned" or contains an excess of foreign matter. The result of a large number of tests further proves that fracture under the drop-test seldom occurs if the steel is homogeneous and free from unsoundness. In other words, mere ability of rails of this composition to withstand the drop-test is no guarantee of fine granular structure, and consequently other tests of quality are essential to necessitate durability. Figs. 1 and 8 represent rails of coarse granular structure which passed the drop-test with good deflection, but such rails do not give satisfactory service.

The foreign matter and gas which produced brittleness was generally found in small cavities or lines scattered throughout the section, but especially prominent within ½-in. from the surface around the head, and caused a series of unwelded seams—elements of weakness. The appearance was usually similar to that of Fig. 2. Rails which did not fracture under the drop-test at the same rolling were found comparatively free from this enclosed matter around the outer portion of the head, though in some cases a considerable proportion was found nearer the web. Still, the solid band of homogeneous material around the outside of the head gave sufficient toughness to the rail to enable it to resist the force of the drop. It is of interest, however, to note that an excessive proportion of foreign matter and gas in rails may not cause failure under the drop-test in cases where the grain is comparatively fine since the strength incident to such structure may offset the weakness caused by the unsoundness. A typical case came under our observation not long ago. A lot of 90-lb. rails had been rolled and had passed the drop-test without a single failure, and the average structure was somewhat finer than that represented in Fig. 3. After being in tracks for a few months a number of the rails began to flow over and break down under the heavy traffic to such an extent that replacement became necessary. Upon inspecting the track we found that some of the rails from the same rolling were in good condition, showing little wear, while others next to them were badly broken down, often along the entire length. The defective rails were not confined to any one heat, but were scattered throughout the rolling. Sometimes the outside edge of a rail was broken down, and sometimes the inside edge. Some in a given heat were showing good service, while one or more from the same heat were defective. Eighty-pound rails of practically the same composition had previously been in this track and had given good service, and had not been broken down by the same traffic.

In order to get at the cause of the difficulty sections of some of the defective rails were obtained, and showed the following average composition:

Carbon	.544%
Manganese	1.005%
Phosphorus	.078%
Sulphur	.090%
Silicon	.120%

There was nothing abnormal in this, and many rails of essentially the same composition have given good results under heavy traffic conditions.

We next investigated the structure of the steel. Fig. 12 represents the general character of the fracture magnified to 1½ diameters, and is a longitudinal section down through the head of the rail about ½-in. from the center line. The striations which appear are unwelded seams which break up the continuity of the steel and produce planes of weakness. In order to learn the extent of these defects, we polished off a full section of the rail and etched lightly with iodin, finding that the entire surface of the section was covered with lines of unwelded seams, as represented in Fig. 11 (reduced 52%). Microscopic examination showed that the steel contained a large number of particles of foreign matter—Fig. 13 (x 50 diameters)—and that some seams were coated with blue and brownish films, evidence that the steel had been burned,* and fully accounting for the failure to weld. Fig. 3 gives a section from center of head, and proves that the rail was worked and finished at a moderately low temperature, and that owing to the consequent fairly fine structure the rails withstood the drop-test in spite of the weakness due to defective manufacture. When laid in track, the weight of the rolling stock caused the unwelded seams to slip apart at the portions where the greatest strain came, thus resulting in the breaking down of the rails. The upper right-hand corner of Fig. 11 shows where a sliver ½-in. thick was forced out of the side of the head along one of the unwelded seams for a distance of several feet, and the crack along the seam extended nearly to the top of the head.

This instance proved conclusively that reliance could not be placed upon the drop-test to ensure homogeneous, solid steel, and it is generally well known that rails of laminated steel may give even a better test under the drop than if composed of solid metal of the same composition.

The above results clearly verify the statement of Dr. P. H. Dudley* that solidity and continuity are quite as important as a good microstructure.

As to the origin of foreign matter in steel, it is evident that it must be due to defective mill practice either in the manufacturing of the steel, including teeming and settling;

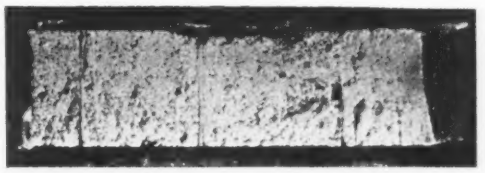


Fig. 12. Magnified 1½ Diameters. Fracture of Rail shown in Fig. 11, Showing Unwelded Seams.

in burning of steel in soaking pits—or in blooming furnaces, if the latter are used—or in cropping blooms or rails; in any event, it is an unquestioned proof of defective mill practice, and is easily avoided if so desired.

In order to ensure the most durable rail of a given composition, our service results, as shown above, indicate that there must be—

(1) Freedom from brittleness.

(2) Absence of unsoundness.

(3) Fine granular structure.

(1) Brittle rails are eliminated by the drop-test of 2,000 lbs. falling 20 ft. upon a rail-butt from the top of the ingot, one rail from each heat being tested, or, in case of fracture, two more being taken from the tops of other ingots of the same heat; fracture of two out of the three causing rejection of all rails in the heat.

(2) Absence of unsoundness is best ensured by careful inspection throughout the manufacture, and by specifying a definite proportion of cropping.

(3) Fine granular structure is necessitated by specifying under definite conditions, the shrinkage of the rail after leaving hot saws—an idea suggested by Mr. Wm. R. Webster.

A shrinkage limit is in operation in most of the mills to-day, but it must be borne in mind that, as pointed out by Mr. Martin in the paper above referred to†, that specifying merely the distance between hot saws does not compel presence of fine grain clear to center of head. Such structure will not result unless the reduction in the passes after the holding is sufficient to work the steel thoroughly to the center.

What is needed is a moderately low initial temperature, sufficient work to render the steel solid, the speed of train and extent of reduction being such that with rapid rolling—without undue holding before or in the last passes, and without artificial cooling subsequently—the distance between hot saws shall not exceed a specified amount.

Under the above conditions, with a given composition, the extent of shrinkage of the rail after leaving hot saws may be made a definite guarantee of size of grain in sections of a given weight, and if the limit is placed at 5½ ins. for a 30-ft. length of a 90-lb. rail, coarse grain even at center of head is practically impossible.

In working toward the most efficient practice in rail rolling, valuable aid has been given during the past few years by Committee No. 1 of the American Section of the International Association for Testing Materials, and Mr. Wm. R. Webster, the chairman, deservedly receives great credit for his efforts in bringing together the various conflicting interests, and in formulating proposed standard specifications of various materials of construction. The specifications for steel rails in particular‡ have aroused wide discussion. In its present form we regard it as tentative, since it merely specifies the quality which, since the introduction of the heavier sections, has everywhere been found rapid wearing and unsatisfactory. It does not ensure durable material, and it does not represent the best American practice.

The specifications proposed to the American Railway Engineering and Maintenance of Way Association§ are an improvement over those of the International Association in inserting a shrinkage clause, but the wording of the

*Trans. A. I. M. E., Richmond meeting, Feb., 1901.

*J. E. Stead: Journal Iron and Steel Institute, 1898, No. 1, p. 183.

*Trans. A. I. M. E., 1893, xxiii, p. 652.
†Iron Age, Dec. 26, 1901.
‡Engineering News, July 4, 1901.
§Engineering News, March 27, 1902.

latter is open to the objection cited by Mr. Martin, and would ensure fine-grained material upon the immediate outer surface of the rail.

Every successful specification is of necessity based directly upon the teachings of actual service. In order, then, to aid the mills in working out the most efficient standard practice, it is greatly to the interest of every consumer to make known the practical service values of the various materials. Our object in entering upon this investigation has been, naturally, to secure the greatest degree of safety and durability in the tracks of the Reading Railway, but we have brought the results to your attention in the hope that a full and free discussion of facts may be of general benefit in tending toward the production of uniformly durable material.

THE PRYOR GAP TUNNEL; BURLINGTON & MISSOURI RIVER R. R.

By F. T. Darrow.*

The tunnel on the "Big Horn Basin" line of the "Burlington" at Pryor Gap, Montana, is in the Crow Indian Reservation, 38 miles south of Billings and 60 miles from Toluca. At the north end of Pryor Gap—a pass some six miles long through the Pryor Mountains—a spur projects into the Gap, and in this spur is located the tunnel, at an elevation of 4,750 ft. above sea level and 250 ft. above Pryor Creek, nearby.

The tunnel is 500 ft. long, located on a 6° curve and on a 1.25% grade against south-bound traffic, equated for curvature to 1.01%. The cross-section is indicated by Fig. 1, the excavation running 18 cu. yds. per ft. and no allowance for excavation being made outside the section.

The formation of the mountain at the tunnel site is a solid dolomitic limestone with strata dipping to the northeast about 5 ft. per 100. This material required no timbering during construction, worked easily with moderate charges of explosives, was easily handled, and made an excellent embankment.

The north approach cut is 350 ft. long and runs to a cut of 96.2 ft., with slopes of 1 on 1, the material being gravel and boulders in clay, except one corner of the cut in the solid ledge, the ledge making an angle of about 45° with the railroad.

The south approach cut is in the solid ledge, with slopes of 4 on 1, except about 5 ft. of broken stone and earth (talus) overlying the ledge. This cut is 275 ft. long. Both cuts are on steep side hill.

At each end is a big fill (maximum 139.7 ft. at the north end and 66.7 ft. at the south), which required much more material than the excavations furnished. The ledge is 130 ft. thick above the top of the tunnel section.

The contractors, J. H. McShane & Co., of Omaha, Neb., began work on Sept. 17, 1900, by excavating wagon trails to the approach cuts. The approach at each end was then attacked at

Fig. 2. View in Interior of Tunnel after Timbering.

grade and at a point about 14 ft. above grade with picks and shovels, drills and powder, carts and later 1½-yd. 3-ft. gage side dump cars. At the north end the upper lift of the cut was stopped when reached by the lower, and this latter carried gradually up till it was some 8 ft. above grade at the portal. Several kinds of traps and chutes were tried, but shovels were finally retained, as being, in this case, the most satisfactory way of loading cars. The cars were run

*Lincoln, Neb.

to the dump by gravity in trains of one, two or three cars and were hauled back by single horses or teams working tandem.

At the south end the lower lift did not materially interfere with the upper until the tunnel heading (which was a continuation of the upper lift) was 300 ft. from the portal, at which point it rested. The material here was also handled by cars and horses.

Early in December, 1900, the south heading was ready to go under, and the circle of the arch was

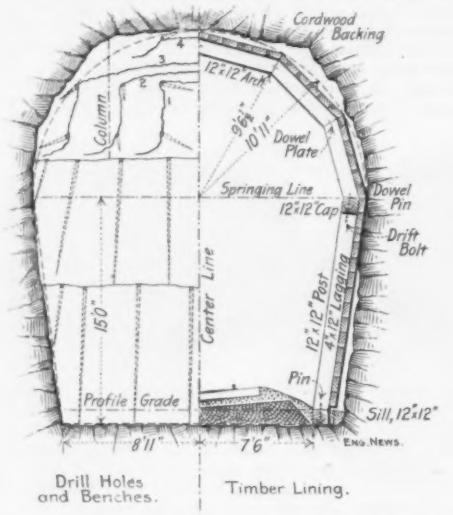


Fig. 1. Cross-Section of Pryor Gap Tunnel; Montana; Burlington & Missouri River R. R.

marked on the rock face. Both hand and machine drills were then started.

The machine drill plant was very simple. At the south end a 16-HP. upright boiler was set up on a shelf excavated in the side of the cut about 80 ft. from the portal and a log house was erected over it. At the north end the boiler was placed in the cut near the portal. The boilers furnished steam for the drills direct, no compressed air being used on the job. The steam was carried in 2-in. and 1½-in. wrought pipe and marline-wound hose to the drills, a final distance of 400 ft. from boiler to drill being successfully operated, notwithstanding the cold weather. Jointed jacketing was used to protect the wrought pipe. Three drills in all were used—two in the heading and one on the bench. They were Ingersoll-Sergeant "arc-valve" size D 9-HP. drills, with 4½-in. column mountings for the heading and tripod for the bench.

The excavation was carried on by a heading and two benches, each about 9 ft. high, and taken out to the full section. Points were given every day and the walls and roof were marked every 10 ft. to indicate the exact state of the excavation. A blue paint, put up in a form resembling shoe-blacking, was found satisfactory for this purpose. The work was carried on by two ten-hour shifts, or 13 shifts a week, and when running well the heading was carried forward 50 ft. per week, the best shift made being 7 ft. The progress on the bench was a trifle better. The force in the heading consisted of a foreman, two drill men, two helpers, six or seven shovelers and one powder man, besides the fireman and teamster outside. The bench force was about the same, except that only one drill and its men were used.

The routine in the heading with each shift was to clear space and get the two columns (one for each machine) set up and the drills mounted; then a set of 14 6-ft. holes was put in and fired in four rounds, as shown on the left in Fig. 1. Then the "muck" was cleaned up. The material of the heading was broken very small by the explosive (60% dynamite), while the bench was not shot so hard and some hammer work was necessary to break up large stones.

The south heading was stopped at 300 ft. on Jan. 20, 1901, and the top bench brought in, the heading gang moving over to the north end, where the heading was turned Jan. 28, meeting the south heading Feb. 23.

Bench work was then carried on at both ends, and the tunnel excavation completed May [illegible]. Three weeks of snowy and rainy weather caused the walls to leak so badly that work was hindered, although a steam-primed siphon, 450 ft. long, was an efficient relief.

No trouble was experienced in ventilating, except that after the headings met the draft through the tunnel was very strong.

Forty pounds of Giant powder (60%) and 1[illegible] lbs. of black powder per lineal foot were used, the latter in bench excavation only.

Several thin talc seams were encountered which allowed some large pieces outside the regular section to fall. On account of the talc seams, the permeability of the rock and the effects of the weather, timbering was put in after the track was laid. Jacob Lampert, of Hill City, S. Dak., was the contractor for erecting the timber lining. Oregon fir timber was used.

There were from six to ten trains per day through the tunnel during timbering, so light scaffolds, easily moved, were employed in erection. The sills, 16 ft. long, were bedded in sand and the posts raised by hand. Caps were placed by block and tackle attached to a light gin-pole resting against the arch of the roof. When the caps had been drift-bolted to the posts and the walls trued up and braced in place, a light scaffold, resting on the caps, was laid across the opening and the arch pieces were raised to the scaffold by block and tackle attached to the last arch erected. Three men worked on the scaffold and one below.

The arch timbers were put in place by hand and braced to the scaffold until the iron dowel plates, ¼ × 5 × 10 ins., were in place, when the arch would support itself. Four arches, 4 ft. c. to c., were erected at one time, and the fourth brought to true position and blocked in place, the intermediates being lined in by eye. Lagging was then placed and the voids behind filled with cordwood, which averaged one-half cord per lineal foot.

The timber portals to protect the entrances are of a different section, vertical posts, 12 × 12 ins., 2-ft. centers, with three inclined braces at the outer end and cross-sills under the track, thoroughly braced in all directions. The roof of the portal is solid and has on it a 1-ft. layer of earth and stone as a cushion. The north and south portals are respectively 27 and 13 ft. long.

The only special machinery used in timbering was a small buzz-saw for notching arch timbers to receive dowel plates, and this was operated by hand power.

After the timbering was complete it was given three coats of whitewash, made with brine. A force pump and hose were used, a plain round nozzle being found most effective. The exposed

Fig. 3. North Portal of Tunnel.

ends of cordwood backing at the portals were covered with rock and lime plaster, and the whole woodwork was thus rendered fireproof.

The main interest in the construction of this tunnel lies in the simple means used in its excavation, on account of the exceptionally good material penetrated requiring but a small outfit of two boilers and three steam drills, the small but efficient force of men employed, its use before being timbered, thus permitting easy delivery of material for timbering, the simple methods of

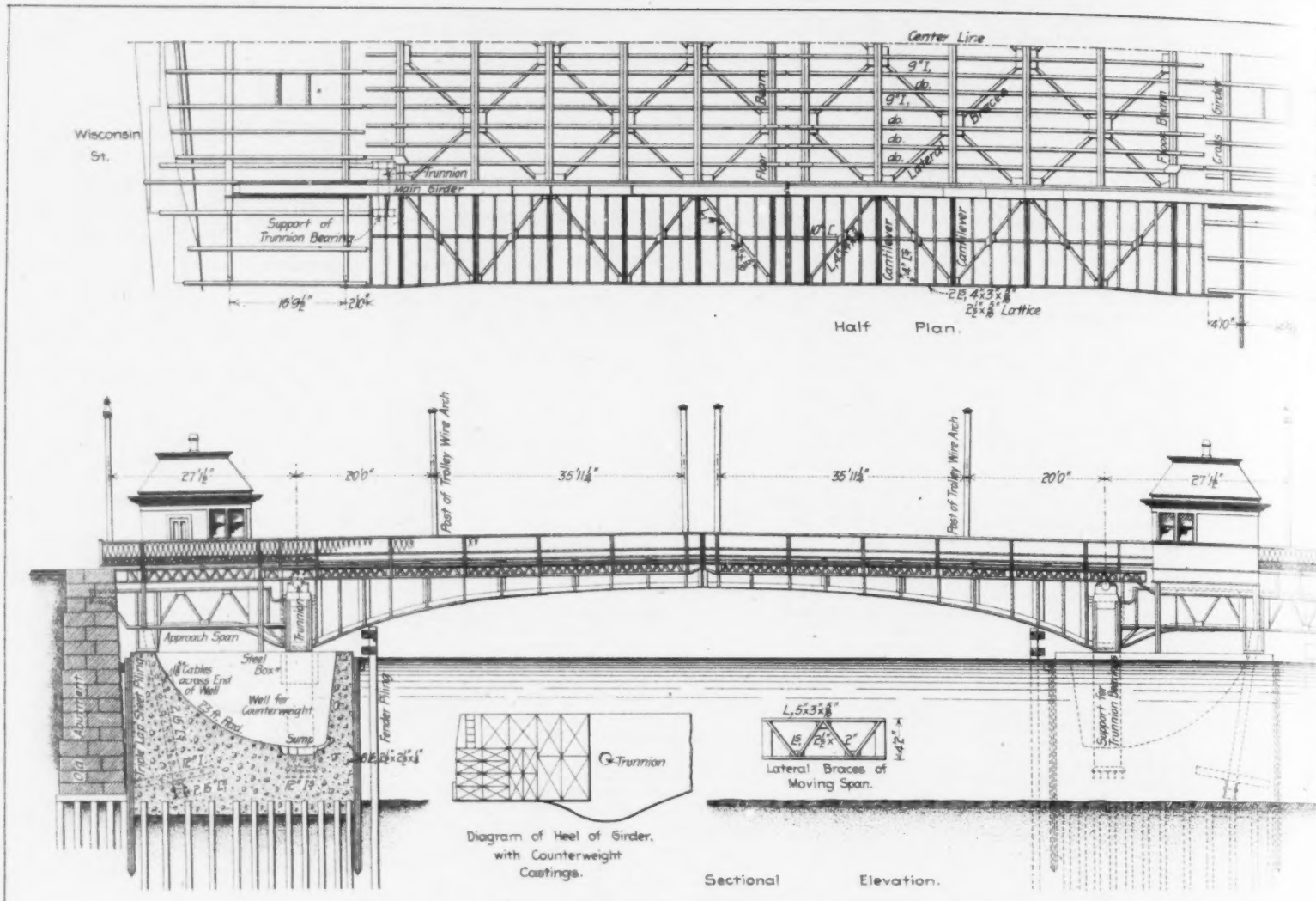


FIG. 2. SECTIONAL ELEVATION AND PART PLAN.

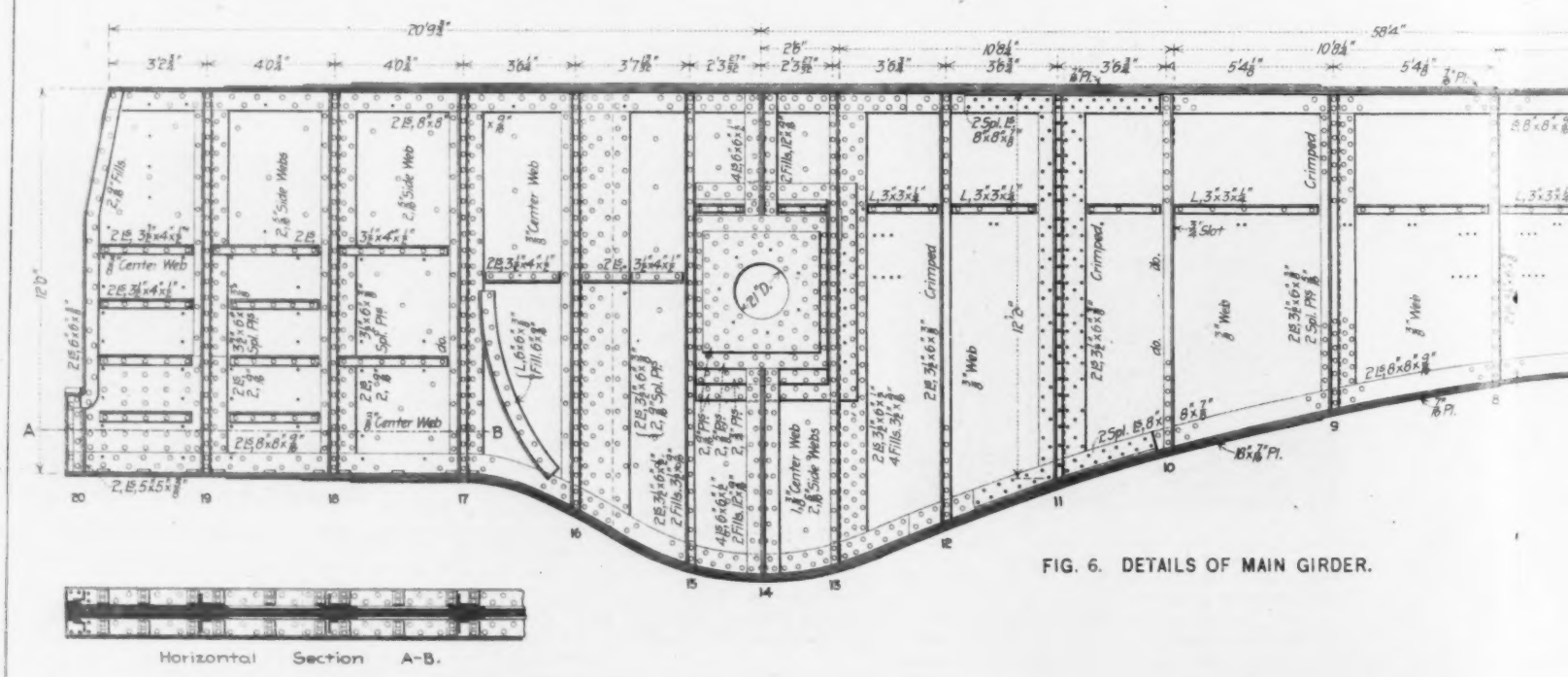
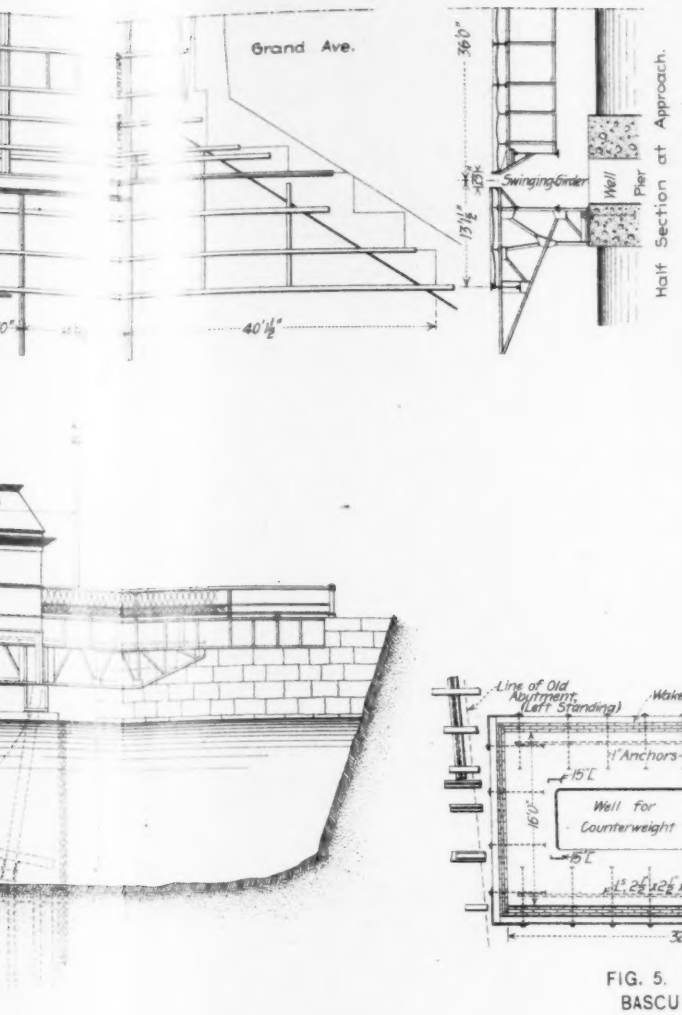


FIG. 6. DETAILS OF MAIN GIRDER.

FIXED-TRUNNION BASCULE BRIDGE AT

Charles J. Poetsch, M. Am. Soc. C. E., City Engineer.



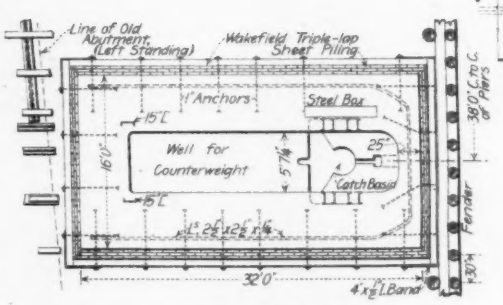


FIG. 5. PLAN OF BASCULE PIER.

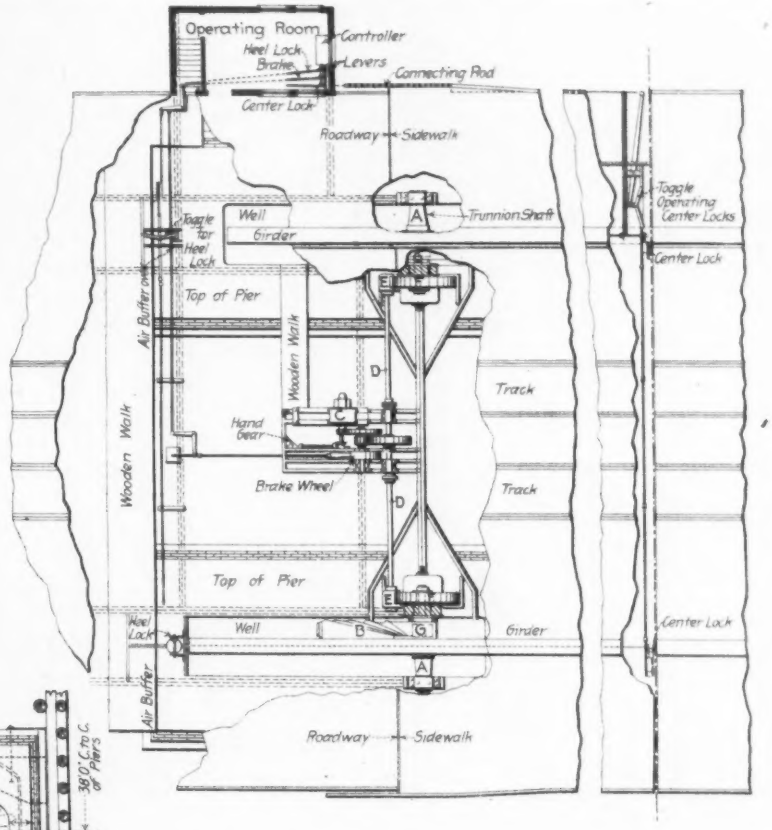
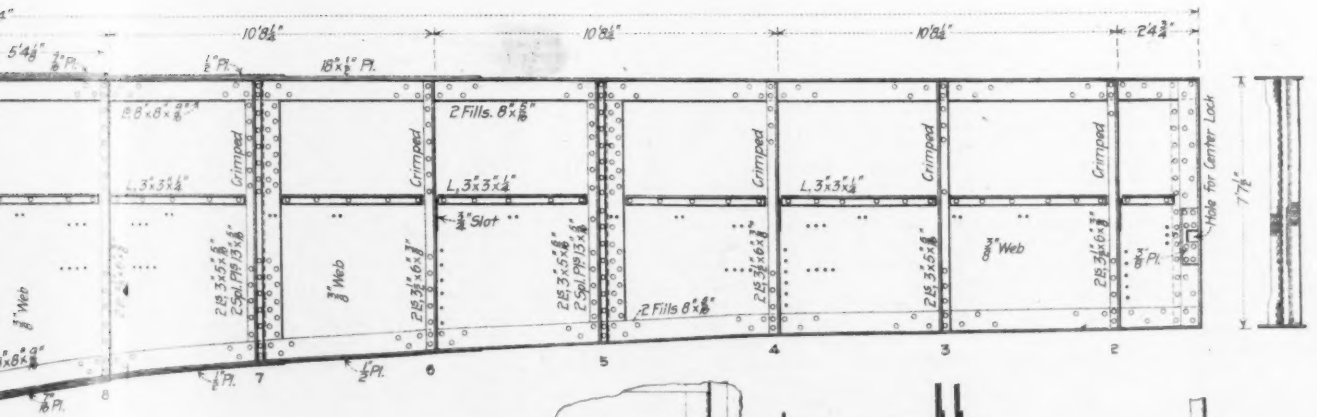


FIG. 8.
PLAN OF
OPERATING MACHINERY.



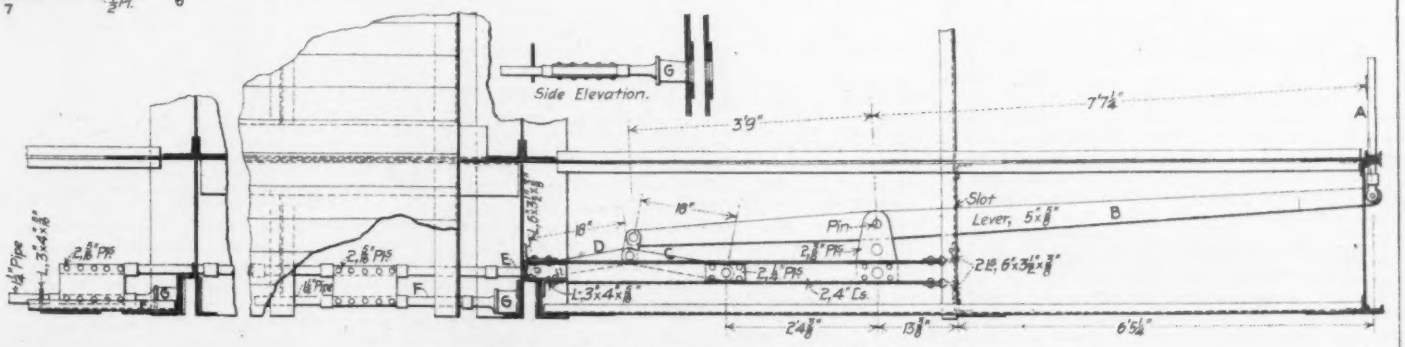


FIG. 10. PLAN OF CENTER LOCKING DEVICE.

BRIDGE AT GRAND AVE., MILWAUKEE, WIS.

Wisconsin Bridge & Iron Works, Milwaukee, Wis., Builders.

CHAS. HART, LITH., 39 VESEY ST., N. Y.

erecting this timber, and, lastly, its fireproof qualities.

This work was carried on under the direction of Mr. I. S. P. Weeks, Chief Engineer of the Burlington & Missouri River R. R., in Nebraska.

ANNUAL MEETING OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

(Concluded from p. 524; Vol. xlvii.)

The session of Friday, June 20, was devoted to papers and discussion on miscellaneous topics belonging to electrical engineering. Five papers and one committee report were presented. A paper by Prof. C. P. Matthews, on "An Integrating Photometer for Glow Lamps and Similar Sources of Light Intensity," which had been announced, was not presented, because of failure of apparatus to arrive on time. As is customary with this Institute, discussion was deferred until all the papers of the group had been read. An exception to this was the committee report, since this in a measure stood by itself. This report was fourth on the morning's program, and was presented for discussion at once. It is placed first in the following abstract of the morning's proceedings:

REPORT OF THE COMMITTEE ON STANDARDIZATION.—Presented by Mr. A. E. Kennelly.

This report embraces the committee's report of 1899 (Eng. News, July-Dec., 1899; p. 30), together with all amendments and additions that have been considered advisable. The changes are all comparatively unimportant.

DISCUSSION.—In reading the report attention was called to the new paragraph 71, referring to the determination of the regulation of synchronous machines. Some discussion arose as to the propriety of including this paragraph, several of the members considering it unnecessary. It was finally voted to adopt the report of the committee with the exception of paragraphs 71 and 42-2, which were referred back to the committee for reconsideration, and then to stand adopted as revised by the committee.

The papers presented during the Friday session were the following:

THE FUNCTION OF SHUNT AND SERIES RESISTANCE IN LIGHTNING ARRESTERS.—By P. H. Thomas.*

This paper describes a new method of enabling an arrester for alternating current circuits to suppress the arc which follows the static discharge. It had been accidentally discovered some years ago that a voltmeter shunted around a non-arcing metal arrester prevented the formation of a permanent arc in the gap. This discovery had later been applied to the large generator switches at the power house of the Niagara Falls Power Co., by using several breaks in series, and shunting a resistance around some of them. In developing this principle for application to lightning arresters, the author discovered some interesting laws of action of such devices, and designed a new type of arrester on this basis.

The complete lightning arrester embodying the shunting principle consists of a number of small air gaps connected between line and ground, a portion of these gaps being shunted by resistance, and a series resistance placed in the earth connection. The shunt resistance is usually placed next the series resistance, and preferably half of the total number of gaps are shunted. It is evident that when the arrester is not in action, the point at the junction of the shunted and series gaps is at ground potential, and consequently that the arrester will discharge whenever the voltage of the line reaches a potential above the ground sufficient to cause the series gaps to break down; that is, the voltage on the line necessary to cause the arrester to discharge, is that required to break down the series gaps alone, regardless of the presence of the shunted gaps.

During actual discharge, the operation of the arrester is as follows: When the series gaps break down, the resistance between the ends of the series gaps is momentarily reduced to practically zero, and the full amount of the potential of the line is then thrown on the shunt and series resistances. If this potential, which is thus abruptly applied to the resistances, is high, the shunted gaps will be broken down. This makes, for the instant, a direct path for the static discharge from line to series resistance. Theory and experiment both show that practically no greater voltage, provided it be suddenly applied, is required to break down both series and shunted gaps than the series gaps alone. This result is due to the fact that the two sets of gaps are broken down separately, one after the other. If conditions are right, current from the generator will then follow the static discharge through the gaps, establishing an arc. The current will flow through the shunt and series resistances and usually through the shunted gaps, but if the various parts are properly proportioned, the shunt resistance will take enough current from the shunted gaps so that the arc cannot hold in the latter and will drop out. Once the arc drops out in the shunted gaps, it must pass through both resistances, which will reduce the current strength, and enable the series gaps to suppress it altogether.

The paper then discusses some of the conditions affecting the operation of arresters, both as to the discharging static electricity, and holding the arc, and the quantitative relations of these conditions to the number of gaps required (assuming non-arcing metal gaps of 1-32-in. each). It next treats of the shunt resistance, and the factors that influence its efficiency; this is followed by an outline summary of the design of a shunted arrester as described. The paper closes with a brief description of the test apparatus used in the investigation.

*Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

THE ELECTROSTATIC WATTMETER IN COMMERCIAL MEASUREMENTS.—By Miles Walker.*

This paper, which was read for the author by Mr. C. E. Skinner, treats of the use of the quadrant electrometer in the measurement of electric power. While the idea is acknowledged to be not new, the subject is here investigated in a practical manner with a view toward commercial application of the instrument. The formulas relating to its operation are deduced, and based on these the proper methods of using the instrument in different applications are shown. In the concluding paragraphs the author points out various sources of error, and discusses the construction of the instrument in various important details. The advantages and disadvantages of the instrument as a wattmeter are thus stated:

(1) It can be made to give very accurate readings at low power factors; (2) It is particularly well adapted for high voltage work, because it does not require a high non-inductive resistance; (3) It is cheap and simple in construction; (4) When constructed for low voltage work, it will not be so liable to be burned out by accident as an ordinary wattmeter; (5) By the use of suitable adjuncts the same instrument can be used to measure any power from 1 watt to 5,000 kilowatts; (6) Its operation is based upon simple laws so that when its needle is controlled by gravity, it can be relied upon as a standard instrument.

But, (1) It is not portable; (2) The controlling forces are in general small, so that the instrument though deadbeat, is slow in reading; (3) Its general behavior must be understood by the operator.

ENERGY LOSS IN COMMERCIAL INSULATING MATERIALS WHEN SUBJECTED TO HIGH POTENTIAL STRESS.—By Chas. E. Skinner.†

Those who have had occasion to test the dielectric strength of insulating materials by means of alternating E. M. F. are familiar with the fact that heat is always developed in these materials during such test. The fact that energy loss exists under such conditions has been known for more than a decade, being first shown by the experiments of Siemens, and later investigated by others. The law of variation of loss, due to variation of voltage, was first announced by Mr. C. P. Steinmetz,‡ early in 1892. At that time Mr. Steinmetz gave this loss the name of "dielectric hysteresis." Since that time other writers have made experiments from which they conclude that this energy loss is not in the nature of a dielectric hysteresis, and various theories have been advanced concerning its nature and cause.

It is not the object of this paper to discuss the theories of the origin or cause, but rather the effects of this loss, and in the absence of a name which can be accepted as descriptive and final, it will be spoken of as "energy loss" or "loss."

The tests to be discussed were made on materials of a fibrous nature, such as paper and cloth, both in the treated and the untreated state (treated—coated with some sort of insulating varnish).

A large number of tests were made to determine the rise of temperature in the interior of the mass under different conditions of stress. The tests were made by placing the material between two metal plates connected to the terminals of a high-potential transformer. Temperatures were measured by a copper-lead thermo-couple bedded in the material and connected to a sensitive galvanometer. The results of the tests are formulated in the paper; they showed the relation of temperature rise to applied potential, time, initial temperature, condition of material, etc. One interesting deduction is that "the final breakdown in fibrous materials usually results from the burning of the material and not from mechanical rupture."

Other tests were made on the energy loss occurring in this process. This was an extremely difficult matter. At first an oil calorimeter was used, but later a static wattmeter was constructed (see paper of Mr. M. Walker noted above.—Ed.) and used for the work with full success. Some important deductions are drawn from the results, for instance, that a long-continued test at high stress may seriously injure the insulation of a piece of apparatus without this being made apparent by the test, the material charring locally and becoming weaker at such points. The loss was found to vary slightly more than the square of the applied voltage. The loss was found to vary with the frequency, but an exact relation has not yet been obtained. The loss increases as the temperature rises, hence at high initial temperature the loss (and temperature rise) is greater.

In conclusion are given results of tests of energy loss in the armature insulation of the 5,000-K W. alternators of the Manhattan Ry. Co. in New York.

THE DETERMINATION OF ALTERNATOR CHARACTERISTICS.—By L. A. Herdt.§

The exacting requirements now to be met in regard to the performance of A. C. machinery and the expense of duplicating in the testing room all the conditions of future operations, make proper indirect methods for the determination of the characteristics of A. C. apparatus of great value.

With this statement as a preface, the paper begins by discussing armature reaction and reactance, and then describes some tests of an inductor alternator showing curves of E. M. F., current, induction, etc., under different conditions, together with check calculations of E. M. F. from the current and the inductance. Then the common method of determining the regulation from the synchronous reactance is shown to be in error. A correct method is then described as follows:

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†Westinghouse Electric & Mfg. Co., Pittsburg, Pa.
‡"Electrical Engineer," March 16, 1892.
§Lecturer in Electrical Engineering, McGill University, Montreal, Can.

The armature, instead of being short circuited, is operated at constant full load field excitation on a suitable variable reactance and the difference between the voltage given by the saturation curve and terminal voltage is noted. The voltage thus obtained divided by the current, gives the value of the demagnetizing component of the synchronous reactance corresponding to normal conditions of machine operation. The cross-magnetizing effect for different in-phase currents is taken as equal to the demagnetizing component of the synchronous reactance multiplied by the ratio of the total inductance of the armature, with the inductor lugs halfway between adjacent coils, to the inductance of the armature with the inductor lugs directly opposite the armature coils. The inductance is determined by passing through the armature, from external source, a suitable alternating current when the lugs are in the position just named, and the fields fully excited.

Using the values so obtained for the demagnetizing and cross-magnetizing components of synchronous reactance, a diagram may then be used to give the E. M. F. under full-load conditions of operation.

The application of this method to an inductor alternator, as well as to a revolving field, distributed winding machine, is then illustrated; the curves obtained by the method described and by the common method are deduced and compared with the observed curve, showing the new method, which the author calls the two-reactance method, to give very close results.

A NEW CURVE TRACING INSTRUMENT.—By Prof. R. B. Owens.*

This instrument was devised for the purpose of tracing curves of current in circuits of small resistance and inductance without appreciably altering their time constants. It has proved generally useful as a laboratory instrument. The instrument consists of (1) two sets of concentric, coaxial fixed coils, each set having an inner and an outer coil, and the two sets being separated a short space in the direction of their axis; and (2) a movable coil, suspended in the center between the two sets of fixed coils, with its plane perpendicular to the plane of the latter. The movable coil is suspended by a bifilar suspension, by which means current is introduced into it, and is fitted with a reflecting mirror, and a damping device.

The action of the instrument is as follows: The variable current of which a trace is desired is introduced into, say, the outer pair of the two concentric coils, a suitable direct current is sent into the inner pair of coils and a contact maker sends an impulse of current from a constant source of E. M. F. through the movable coil. If the direct current in the inner fixed coil is equal and opposite in magnetic effect to the instantaneous value of the variable current at time of contact, no deflection of the movable coil will be observed. If a deflection, however, does occur, the direct current is varied until such deflection becomes zero; then the direct current, as read by an ordinary Weston ammeter, equals to within a readily obtainable constant the instantaneous value of the variable current for the particular setting of the contact maker used. Shifting the contact maker arm, as many points may be obtained as are desired.

The instrument is extremely sensitive, allowing perfectly satisfactory traces of currents a fraction of a milliampere effective value to be obtained, and its range can be varied to almost any extent by the addition of fixed coils. When measuring very small currents, it must, however, be shielded or corrected for stray fields. Briefly, the advantages of the instrument are as follows: (a) its indications are independent of the constancy of contact, being a zero method; (b) all readings are of instruments of the Weston direct-current type, and can be readily converted to absolute values; (c) wide range and great accuracy; (d) it can be quickly and easily manipulated and has a minimum resistance and inductance.

Some of the application to which it has been put are: (a) the tracing of alternating E.M.F. and current waves; (b) obtaining curves of growth and decay of current in inductive circuits, when constant E. M. F.'s are applied; (c) obtaining curves of rate of growth and decay of such currents; (d) obtaining leakage coefficients of large generators, the time constants of whose fields make the use of ballistic or of damped galvanometers for accurate work impracticable; (e) the determination of the variation in a single revolution of the angular velocity of engine flywheels; (f) the determination of the fluctuations in currents from commutating machines.

The variation in a single revolution of the angular velocity of an engine flywheel is measured as follows: A disk dynamo with fields constantly excited is directly driven from the engine shaft and the current trace from it obtained as a function of the angular displacement, such current at any instant being proportioned to the angular velocity of the flywheel at the same time. It is necessary to use a disk dynamo or one having a great number of commutator segments, as otherwise the variations in the current due to the angular displacement of adjacent armature coils will mask the variations due to a change in angular velocity.

DISCUSSION.—In connection with Mr. Skinner's investigation of losses in dielectrics, Mr. Nichols mentioned that he had once attempted to determine the change in length of tubes of insulating materials under electrostatic stress. He had found that the resulting heating was so considerable that the expansion produced by it masked the change in length due to dielectric stress, and thus made the experiment impossible.

Mr. F. A. C. Perrine was much interested by the paper of Mr. Thomas describing a new lightning arrester. He pointed out that the resistances used (shunt and series) would have to be comparable with the resistance of the circuit as a whole, and thus in many cases they would run up into great figures. He thought that for power-house purposes the new type of arrester might prove very useful,

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but he doubted whether it could be used on a long transmission line or cable. Referring to Mr. Skinner's paper on dielectrics, he noted the similarity of the curves shown to those obtained by tests on cables, with gutta percha insulation. In cables the effect of moisture in causing greater heating had long been observed; he thought that this greater heating was to be charged to electrolytic conduction, since he had found a storage battery effect in all such cases. He stated that Mr. F. J. Newbury, of Roebling's, had found that fiber (also rubber) insulated cables showed an increase in dielectric strength, as the insulation was increased in thickness, up to a certain critical thickness; beyond this the dielectric strength remained practically constant. This was probably due to vacuous spaces in the insulation, which could never be entirely eliminated.

Mr. Elihu Thomson agreed with Mr. Perrine in thinking that knowledge of the behavior of lightning arresters on long transmission lines and cables must be gained on such circuits directly, since the conditions can never be completely reproduced in the laboratory. Referring to the observations of Mr. Newbury quoted by Mr. Perrine, he thought that the effects might be in part explained by the fact that the potential gradient at the surface of the wire is not much affected by an increase in thickness of insulation, but would cause failure when it rises beyond a certain point. Weak points in the dielectric concentrated the radial stress and thus determined the point of failure. The same thing is true in case of a film of oil on the boundary between a dielectric and a conductor; the unavoidable thinner places in the film caused a concentration of the stress at these points and thus caused rupture at a lower stress than if the film of oil were absent.

Mr. C. O. Mailloux mentioned some tests of insulation strength with a resinous dielectric which softened with the heating. In tests on plates of this substance the material at the point of breakdown seemed to flow, as under an applied pressure, causing a thinning of the plate at that point, just previous to the rupture.

President C. P. Steinmetz, speaking of lightning arresters, analyzed them into three parts: a series resistance, a spark gap, and cooling surfaces at the terminals of the gap. The resistance damps out the surges and oscillations of potential, the gap defines the relative voltage required for sparking and arcing, the cooling surfaces dissipated the heat produced. He sketched out curves showing variation of voltage required for sparking and arcing, respectively, with the length of gap, the curves intersected at a comparatively small gap-length, the sparking curve rising above the other. Thus, a multiplicity of gaps is required, the sparking voltage remaining constant, while the arcing voltage increased with the number of gaps. Speaking of energy losses in dielectrics, Mr. Steinmetz stated that he had worked on the subject for quite a number of years and had not got to the bottom of the question yet. Working with paraffine, he had reached power factors as low as 0.4%, yet thought that even these losses were largely accidental or incidental rather than due to any inherent quality of the dielectric.

Mr. C. E. Skinner had noted mechanical effects just previous to the rupture of a dielectric similar to those observed by Mr. Mailloux. In testing glass under oil he had observed chipping of the glass along a line, forming a noticeable groove.

Mr. E. B. Raymond, speaking from experience gained in many hundreds of commercial tests, stated that the ordinary method of finding the regulation from synchronous reactance gave results very closely correct. Some discussion ensued on this point between Prof. Owens, Mr. Raymond and Mr. Steinmetz.

The session of Saturday, June 21, was given up to the subject of Electrical Engineering Education, with six papers. A paper was also presented dealing with a matter foreign to this subject. It brought out no discussion of moment, and is placed first in the following series of abstracts:

A VARIABLE-RELUCTANCE METHOD OF MOTOR SPEED-CONTROL.—By G. F. Packard.*

This paper treats of a multi-speed motor which was fully illustrated and described in Engineering News of May 1, 1902. The construction was patented by Mr. F. A. Johnson.

PRESIDENTIAL ADDRESS.—By President C. P Steinmetz.

This address first considers the rise of science and its close interdependence with education, and then proceeds to analyze the needs of the latter on this basis. The whole address is full of excellent suggestions. The following are extracts:

One of the reasons of the inefficiency of the present college course is the competition between colleges. By trying to teach more than other colleges, gradually the quantity of material taught by our colleges has increased so that it is not possible any more to give a thorough understanding, and memorizing takes the place of understanding. Memorizing, however, is an entirely useless waste of energy, since anything that is not perfectly understood, but merely memorized, will be forgotten in a short time if not continuously applied, and if continuously applied it would be remembered anyway. If of the amount of material in electrical engineering as well as other branches which the educational institution of to-day attempts to teach, one-half or more would be dropped altogether, but the rest taught so as to be fully understood, with special reference to general principles and methods, the product of the institution would be far superior and more successful in practical life. To be dropped, then, are all formulas, rules, etc., beyond the most simple ones, of the scope of the multiplication table, etc. When needed, formulas can be derived from the fundamental principles or looked up in the literature, and their memorizing is a mere waste of valuable time, useless since the memory cannot retain them if the understanding cannot reproduce them from their premises. This, for instance, applies to the various formulas of electro-magnetic induction, the equations of the transformer and other apparatus, and theoretical investigations in general.

Still more than in electrical engineering this applies to the allied branches of science and engineering, of which the electrical engineer should have a fair understanding. Here anything beyond fundamental principles is objectionable. The electrical engineer should understand the principle of the steam engine, of the hydraulic turbine, know why the spouting velocity and the peripheral speed of the water wheel are related to each other theoretically, and how this relation is modified actually, but should not memorize the mathematical theory of the turbine with its half dozen unknown friction coefficients. He is not expected to design turbines, and if he did, his design would surely be a failure, but he is expected to understand the turbine, the steam engine, etc. The engineering graduate should know the principles of the strength of materials, the distribution of forces in the loaded beam, the reasons leading to the I-beam, to the triangle in bridge and roof construction, but time should not be wasted in calculating bridges or deducing elastic curves, etc.

What, then, should an ideal electrical engineering course contain?

Of mathematics, plain and some solid geometry, arithmetic, and a good knowledge of algebra. Plain trigonometry—no spherical trigonometry required—and a thorough understanding of analytical geometry and of calculus, but no memorizing in integral formulas, etc.; they can always be looked up in a book when needed.

A thorough knowledge of general physics, especially of the law of conservation of energy, which I am sorry to say is not yet an integral part of our thinking, and of chemistry, especially theoretical chemistry and chemical laboratory, in the latter freely using tables, etc.

The electrical laboratory work should be taken up right in the beginning. Even before taking up the theory of apparatus, the theoretical investigation of alternating currents, self-induction, transformers, etc., the student should have met these phenomena and handled the apparatus in the laboratory. Only after seeing the effects of self-induction, for instance, on the alternating-current circuit in the laboratory, the theory of self-induction will have any meaning and make an impression on the student. What the student has seen practically in the laboratory he will then take up in the theoretical course, to understand it, learn to calculate and control, and afterwards going back once more to the laboratory, apply it.

Design of electrical apparatus is of very secondary utility and rather objectionable, with the exception perhaps of some very simple apparatus. The considerations on which designs are based in the engineering departments of the manufacturing companies and especially the very great extent to which judgment enters into the work of the designing engineer makes the successful teaching of designing impossible to the college. Far better is the reverse operation, the analytical investigation of existing apparatus, and more instructive to the student. That is to derive from existing first-class apparatus by measurement and test, the constants of the apparatus, and to calculate these constants and compare them with tests. Besides, a very small percentage of the college graduates enter the field of designing, but most of them will have to handle apparatus, and it is therefore very much more important to be familiar with the completed apparatus in all its characteristic features, in normal and in abnormal operation, than to be able to design it.

The preceding naturally can be a short outline only of the work which I consider appropriate to an electrical engineering course, but I believe the general principles of the course can herefrom be understood. They are to give the student all the ground work required to be successful in future practice, but not the impossible aim of giving him a complete education as practical engineer.

CONCERNING UNIFORMITY IN THE ELECTRICAL ENGINEERING COURSES IN THE UNITED STATES.—By Samuel Sheldon.*

Inquiry of employers reveals the fact that there is considerable dissatisfaction with graduates, irrespective of whence they come; that employers prefer to do their own special training and to supply the graduate with his special facts; and that employers consider that the average graduate lacks something, and this something is variously and often vaguely defined as: "initiative of thought and action," "breadth of training," "breadth of thought," "training in fundamental principles," "horse-sense," etc.

An attempt is made to find why this is so. A table is given which shows that the distribution of time among the different subjects in the electrical engineering course is very different in the different technical schools in the country. The inference is that some schools waste time on certain subjects, while others err in the opposite direction.

Perhaps that which the present graduate lacks is the broad-mindedness associated with graduates from classical and art courses and which, as a whole, is considered as an indication of a liberal education. The results which the liberal educator aims to achieve in his student are the following: (1) To discipline his mind so as to create a power for co-ordinate thought; (2) To impart to him a knowledge of facts; (3) To develop a power of expression in language or in action; (4) To discipline his emotional sympathy so as to develop an æsthetic taste; (5) To discipline his moral faculty.

The first three are also the aims of a technical education and are accomplished through the study and treatment of special facts lying in a very narrow field.

The facts employed by the liberal educator are drawn from the whole domain of human knowledge and are purposely chosen so as to give the student a superficial and general survey of human achievement.

The average graduate from a liberal course possesses a breadth of culture which is easily distinguished as being in excess of that possessed by the average technical graduate. The two courses have so many immediate purposes in common that this difference might be largely eradicated by a single carefully planned course of lectures.

THE EQUIPMENT OF AN ELECTRICAL ENGINEERING LABORATORY.—By R. B. Owens,*

This paper describes the arrangement and equipment of the electrical engineering laboratory at McGill University. This laboratory is planned on a very liberal scale, and is arranged and equipped very elaborately and conveniently. The generators, arranged in two bays, are motor driven; each bay is provided with a traveling crane. All machines are connected to a switchboard. Tables for apparatus are arranged along the sides of the room. A number of conveniences, such as rolling transformer stands, are described.

ELECTRICAL ENGINEERING COURSES AT COLLEGE AND THE EDUCATION OF THE ELECTRICAL ENGINEER.—By Wm. Esty.†

The author first calls attention to the greatly changed conditions in engineering as compared with the conditions of one or two generations ago. This has called for a higher standard of technical education, and the standard is still constantly tending upward. Following recent tendencies in law and medical colleges, engineering colleges should also call for a general university education to precede the technical course. Many such colleges have for some years worked in this direction, as by making it possible for a graduate from a university course to complete an engineering course in two additional years.

Assuming that this six or seven-year course of training for the engineer is a thing of the future, how can we best arrange the studies in a four-year course, to suit the needs of to-day? The curricula of the different engineering colleges show an average of 10 to 20% of the time to be devoted to culture studies. The author believes, however, that most of this time is wasted, since it is a common experience that it is impossible to teach culture subjects effectively in a course with decided technical tendencies.

The problem of proper curriculum is most serious in electrical engineering courses because the whole subject, and especially certain divisions of it, are of so very recent origin and are even at present in rapid growth. The question of text-books is a serious one on this account and also because those who know do not write the books. Further, while the achievements and constructions of civil and mechanical engineering are fully described in the contemporary technical journals, information made public in regard to electrical machinery and construction is very scant.

A common complaint among practicing electrical engineers is that college graduates are not practical. While this is in part a necessary consequence of our scheme of education, it is possible to some extent to keep the student in touch with current practice and affairs. Thus, the study of trade literature, of illustrations of machinery, etc., as actually constructed, the inspection of plants and works, and frequent lectures from practical men and specialists, are recommended to this end.

The author further adverts to the laboratory work, to the study of design, to seminary instruction and to thesis work. In particular the author strongly believes in the teaching of design as a class-room subject, believing that it will give an effectiveness to the theoretical instruction which is not reached in other ways. Finally, the author advances the following as safe rules: Teach thoroughly those things which are fundamental; devote little time to highly specialized subjects; introduce the student to those branches of knowledge which in his later life he can acquire, if at all, only with increasing difficulty; cultivate in the student a thirst for knowledge so that he will remain a student through life.

THE EDUCATION OF THE ELECTRICAL ENGINEER.—By H. W. Buck.‡

The author remarks on the rapid development of electrical engineering and the highly scientific state it has already reached. In this connection he points out that in the past electrical engineers have attained their positions from widely different courses of preliminary training, and that there has in consequence often been a difference of opinion as to the proper course of training for those intending to become electrical engineers. Referring to the difference in this respect between the theoretical and the practical men, the author asserts that many instances can be cited of men who have been prominent as electrical engineers who have been dropped out of place, in the course of the rapid progress which has been made, on account of a lack of theoretical foundation in their knowledge. Yet, though the engineer needs a special education in the theoretical branches on which his work touches, theory alone is not all; the physical meaning of the theory must be brought out by constant association with actual apparatus which demonstrates the application of the physical law.

The author then outlines his idea of the proper course of training for the electrical engineer. He first specifies

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certain features in the preparatory school and the college training; after graduation an apprentice course should be pursued in some large electrical manufacturing establishment, and after a few years of this training specialization may begin along the lines selected for the life work, but preferably not before.

Attention is also directed to the other qualifications necessary to the engineer for success—executive ability, presence of mind, etc., etc. These elements cannot be acquired in the study of theory and practice alone. Almost above all comes a training in the English language. No man who cannot express himself clearly and concisely in writing or in conversation can hope to attain a prominent position in his profession.

A PROPOSED REFORM IN TECHNICAL TRAINING.—By E. B. Raymond.*

This paper is a most severe arraignment of the college graduate and the system that produced him. The author first makes the charge that most college graduates are lazy. Young men who have been reared without due consideration of the economy and self-denial which has enabled their parents to support them while they were being educated do not take their life work with the necessary earnestness, and are apt to drift along without thought as to whether or not their efforts are tending in the proper direction.

The author holds that the specialization in education should begin early. When a boy enters the high school either parents or teacher should decide upon the line of his life work. Coming to the college course, the writer strongly advocates fostering a more earnest and practical spirit there. Our professors should be men of force of character as well as intellectual attainment, and the courses at college should be so arranged that recitation rooms and laboratories may be regarded by the students as we look upon our offices. The colleges should return to the district school principle by stopping elective courses, contracting the list of studies and by encouraging the students to specialize. The technical college should drop from its curriculum studies which are likely to be taken up after graduation. When properly trained, the graduated engineer will devote a portion of each week to study, and will do this from a natural inclination to study. The author suggests, therefore, that from college electrical courses such studies as French and German, rhetoric and English composition, history, English literature and political economy be dropped. In place of the studies discarded, more stress could be laid upon mathematics, physics, chemistry, mechanics, thermodynamics and the laws of electricity.

DISCUSSION.—Mr. F. A. C. Perrine considered that Mr. Steinmetz alone of the morning's speakers had attacked the subject in the right way. The old educators, he thought, had had the right idea, to train in the humanities; only to-day it is science that is the real "humanities," the study of which develops the human being, the man. This should apply as much to technical colleges as to any other. In college the mind should be developed and a groundwork of knowledge laid, leaving the technical detail to postgraduate time. He would say to the technical educators, do not teach a man to get a position; teach him that he may hold a position! Mr. Perrine then criticised much of the modern laboratory instruction, saying that its refinement had been carried too far in many places. Lastly, referring to college professors themselves, he strongly insisted that these should be men taken from practical life, and that even while teaching they should now and then spend a year in practical work, so as to keep in touch with practice.

Mr. Wm. Stanley disagreed most heartily with Mr. Raymond. The training advocated by the latter would take away all the student's capacity for enjoyment, would make him a machine, it would entirely suppress the development of the imagination, and thus would make invention impossible.

Prof. W. E. Goldsborough made an extended and warm defense of the college professor and the course of training he has developed, having special reference to the remarks of Mr. Perrine. He said that the course of training advocated by the latter was not generally possible, because the students lacked the time, the money or the ability necessary. He claimed that students educated on that plan would be useless to employers, and therefore could not find employment after graduating. He defended competition between colleges, which had been blamed by some of the speakers for overdevelopment of attractive and superficial features of engineering courses. He then pointed out that a student always learned less than was taught him, and that to give him the fundamentals you must teach him more than just these. Prof. Goldsborough believed in broad training, as broad as it could be made. On this score he also defended memorizing, which had been denounced in the address of President Steinmetz. Memorizing is excellent mind training, and gives the student something he does not get in other ways.

Mr. E. B. Raymond emphasized the idea expressed in his paper that the "useless" studies should be eliminated from the college course, those that can without loss be taken up later by the student himself. Others cannot be so studied, but must be taught during the college course, and these should be enlarged upon.

Prof. C. A. Adams believed in studying the application of principles to get at the fundamental principles themselves. On these grounds he believed in teaching design, and thought that it could be made very advantageous. He called attention again to the practical difficulty met with by the educator in that he had to handle large classes, which made it impossible to follow courses planned out on the basis of the individual.

Prof. C. P. Matthews considered that much of the poor success of technical education was to be charged to boys following a line of study and life work that they are not fitted for. For this very reason he did not believe in starting to specialize very early in life, as, for instance, was advocated by Mr. Raymond.

Mr. F. S. Pearson, speaking from the point of view of the constructing engineer, stated that he believed the proper thing to do for one who intended to follow engineering as a profession was first of all to make himself a good engineer; the salary and other matters would follow of themselves. Mr. Pearson expressed firm belief in the thorough teaching of French and German to engineers, together with some Latin and Greek.

Mr. C. O. Mailloux felt similarly in regard to languages. He would lay more stress on Latin as a culture study and as a recreation. The speaker confessed to having kept up his Latin from his early school days, stating that the only magazine he read regularly at present was a Latin one. In regard to theoretical and practical study in technical colleges, Mr. Mailloux asserted that very often engineers are not practical enough because they are not theoretical enough; if you teach the fundamentals of theory you will at the same time teach the fundamentals of practice.

A number of other speakers besides those mentioned above took part in the discussion, touching on minor points. All present manifested great interest in the subject. The diversity of opinion in the discussion was much less marked than in the papers. For instance, the radical views advanced by Mr. Raymond found no support. On the other hand, those who would expand the college course and make it general and liberal, and those who would compact the course and make it more practical, found in discussion that they were on common ground in desiring as thorough and broad an education as could be given with the time and opportunity at disposal. The discussion would doubtless have continued at much greater length had it not been for the extreme lateness of the hour, which rendered it necessary to cut the meeting short. The session, and with it the convention, was adjourned at 2 p. m.

INVITATION FOR JOINT MEETING WITH THE INSTITUTION OF ELECTRICAL ENGINEERS OF GREAT BRITAIN.

A matter not referred to in the preceding came before the convention at its Friday session. Prof. R. B. Owens, on behalf of McGill University and the city of Montreal, invited the Institute to hold its convention of 1903 in that city. He suggested that it was possible the British Institution of Electrical Engineers might meet there at the same time, an invitation having been sent them. The Institute acknowledged the courtesy of the invitation. It was then proposed to resolve to meet in Montreal in 1903 and to invite the Institution to meet with it in Montreal. This matter was thoroughly talked over, particularly with a view to the fact that the Institution, or at least many of its members, might wish to come to America in 1904, the time of the St. Louis Exposition. It was finally resolved to invite the British Institution of Electrical Engineers to hold a joint meeting with the American Institute of Electrical Engineers, the date and place being left for future arrangement.

*General Electric Co., Schenectady, N. Y.

A SEVERE TEST OF A STEEL DUMP CAR

In our issue of July 11, 1901, we illustrated and described a new type of dump car, put on the market by the Ingoldsby Automatic Car Co., of St. Louis, Mo. A wooden car of this construction built for the Colorado & Wyoming Ry. was given a severe test under a load of 160,600 lbs., and the results were described in our issue of April 10 last.

Still more recently, a steel car for the Colorado Steel & Iron Co. was subjected to a still heavier loading at the Detroit works of the American Car & Foundry Co. The following is the report of this test made by Mr. J. R. Bowling, M. E., and furnished to us by Mr. F. S. Ingoldsby, Vice-President and General Manager of the Ingoldsby Automatic Car Co. We are also indebted to Mr Ingoldsby for the photograph here reproduced:

Complying with your instructions to make a loading test with one of the 100,000-lb. capacity all-steel Ingoldsby patent dump cars now being built at Detroit for the Colorado Fuel & Iron Co., the American Smelting & Refining Co. and others, I beg to report as follows:

INGOLDSBY STEEL DUMP CAR TESTED WITH 200,000 LBS. LOAD.

Loading of car was started April 10, and was loaded to 84,100 lbs. of Bessemer pig iron by April 11. Car was drawn over frogs, around curves, over switches and over obstacles placed on track, and was buffed into other cars and showed no defects.

Car was additionally loaded on April 12 with Bessemer pig iron to 147,000 lbs. and was then bumped about over frogs, switches, obstacles on track and around curves, and was sent flying into train of box cars loaded with pig iron and was uninjured. The two front cars in this train had their ends smashed outward; the first of these two having all end posts badly broken.

Car was then additionally loaded on April 15 to 200,100 lbs. (additional load consisting of No. 4 foundry pig iron). Car was then drawn over frogs, switches, obstacles and around curves, and was sent flying into flat car standing still. This flat car is practically useless until thoroughly overhauled and repaired, as it has four journal boxes completely smashed, and the car body moved some 6 inches forward on both trucks, bending center pins and crushing truck and body bolsters that amount. The steel car showed no defects whatever. Car was switched around several times, and allowed to stand until April 16, when it was placed on "pig iron switch" and the No. 4 foundry pig iron was unloaded by hand, as it was desired that this be not dumped with the Bessemer pig iron for fear of mixing and causing unnecessary time in separating. Car was moved further on same switch and then dumped one side at a time, and showed no lunge or sway when first side was dumped. One man unloaded the 147,000 lbs. of pig iron by hand power in about ten seconds.

In the matter of the deflections under the 200,100-lb. load, the greatest possible uniformity was shown throughout the entire car, and at no place exceeded ⅝-in. after all the parts had settled into place.

The permanent set was as follows:

At center of one center truss	5/16 in.
At center of other center truss	¼ "
At ends of bolsters and at side bearings	3/16 "

COAL-LOADING TEST.—This same car was now loaded with Hocking Valley (Sunday Creek) run of mine bituminous coal, and the coal load in the car was found to weigh 138,600 lbs. The load was crowned to a little higher than the average crown given, but was not too high for shipment, as was evidenced by our running the loaded car over the tracks and around the yards.

The outward bulge of the sides due to this excessive loading only amounted to 1/16-in. on each side, making the total increase of width between sides of car at top, ⅛-in.

The above reported test is one of the most graphic illustrations we have seen of the serious effect upon the draft rigging and structure of ordinary wooden cars that results from buffing shocks with the modern large capacity steel cars.

Further, the test gives a not unimportant hint of what the near future may bring forth in the way of heavy car loading. When the 100,000-lb. car was first brought out, it was generally understood that it would hold its rated capacity only when loaded with some heavy material like iron ore, and would fall considerably below its capacity when used for soft coal. The car here-

with illustrated, however, has sufficient cubic capacity, as is evident from the above test to hold at least 110,000 lbs. of soft coal, and from the test above it appears that the car itself will give no sign of distress if the traffic manager gives it a load of iron ore instead of coal. Such a load might easily concentrate nearly 100,000 lbs. on each four-wheel truck.

The problems which such a prospective loading brings before the bridge designer, rail maker, wheel founder, and all railway mechanical officers, need only be referred to to be appreciated.

METHODS OF MEASURING DREDGED MATERIAL IN THE CHANNEL IMPROVEMENT OF THE DELAWARE AND SCHUYLKILL RIVERS.

In the April number of the "Proceedings of the Engineers' Club of Philadelphia" Mr. C. H. Ott presents a paper upon the work done by the city of Philadelphia in supplementing the government work for the improvement of the Delaware River channels. He gives the history of this work, its arrangement, disposal of material, plant, cost,

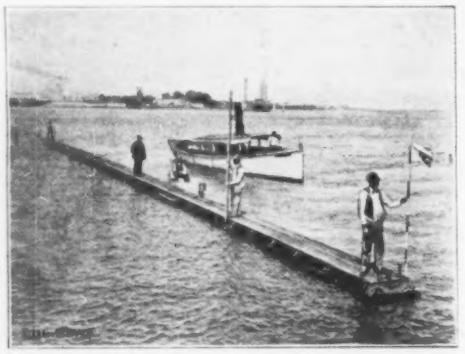


Fig. 1. Sounding Raft; Delaware River Improvement.

etc. But the most generally interesting portion is that relating to the surveys and methods of measuring and testing the dredged channels, and to this part the following notes refer:

The surveys included the usual triangulation, tide gaging, soundings for original and finished bottoms of channels, measurement of quantities in scows and in impounded basins, the location of points for setting channel and cross ranges, etc. In the later contracts the following method of measurement was adapted as being most satisfactory to the city engineers and to the contractors: All material other than rock or wreckage was measured in the scows at place of deposit. Ledge rock to be removed was measured in place in the ledge. The ledge was uncovered by dredging and stripped clean of all loose and overlying material. A careful survey was then made to ascertain the surface, extent and quantity of rock to be removed, and this quantity thus ascertained was final, no further measurements, allowances or payments being permitted within the limits of the area thus stripped and surveyed. Boulders of 10 or more cubic feet excavated during the stripping or dredging of loose materials were measured on the scows as rock, and wreckage was paid for on estimates based on measurement of the material as piled ashore in compact form.

In surveying the ledge a catamaran raft was used. This was made of two white pine spliced sticks, each 14 × 14 ins. and 152 ft. long, placed 10 ins. apart. These two sticks were connected by ties 4 ft. apart, and two running boards, each 14 ins. wide, were fastened to these. The running boards were graduated at 5 ft. intervals, running from zero to No. 30; and the raft was equipped with mooring rings, chains, cleats, six light anchors, 1,000 ft. of light galvanized steel wire rope (7 wires of No. 20) and 1,000 ft. of 12-thread manila rope.

This raft was brought into position longitudinally with the current and held in position by up and down-stream anchors with about 500 ft. of rope; it was held in position transversely by two other anchors. Each pair of anchors was connected by a light continuous wire cable, about 500 ft. long; one of these cables passed across the bow and the other across the stern of the raft, and in crossing it was given a turn around stanchions provided for that purpose. The raft was moved laterally by hauling on these cables, the moves usually being parallel and 5 ft. apart. The soundings were made with a round wooden pole, about 30 ft. long, tapering from 2¼ ins. to 1¾ ins. diameter. One end of this pole was fitted with a steel spike ⅝-in. diameter and 2 ft. long, and this piked end was weighted with sheet lead, so that the buoyancy of the pole about equalled its displacement at a vertical immersion of 25 ft. The pole was graduated by branding at each foot and fifth of a foot.

In operation this pole was thrust into the water sufficiently ahead of the bow of the raft so that the current and the work of the leadsman caused it to assume a vertical position opposite the zero point on the running board. This action was repeated at each of the 5-ft. positions along the raft, the sounding being announced for each. The pole was not withdrawn from the water in this sounding, but was carried along by the leadsman, only being lifted sufficiently to clear obstructions. The average time for making a line of 31 soundings was about two minutes, and about 12 lines of soundings were taken in an hour. In the Delaware River these soundings were only made during the ebb-tide, as the flood-tide carried the pole along too swiftly to permit correct reading. The work was checked by frequently overlapping the moves of successive days and thus sounding over the same areas; the profiles were found to be practically identical.

In testing the bottom of the channel after excavation to determine if all rock had been removed above the fixed planes, this same raft was employed, with a light steel triangle, with a base of 5 ft., substituted for the pike on the end of the pole. By means of an adjustable gage mark on the pole, the required depth was set off on the pole and the test was made. Guide marks on the pole enabled the leadsman to keep the sweep transverse to the line of test. In sounding, an average day's work, during the full elevation of an ebb-tide, covered an area of 150 × 200 ft., with 1,240 soundings. The sweeping could be done on either tide, and usually covered 150 ft. long by 400 ft. wide in a day's work.

In testing excavated channel bottoms for completion, where ordinary material had been removed, a rowboat sweep was used. This was a 1½-in. iron pipe, 10 ft. long, with 1¼-in. tees at the ends. Sliding through each tee was a ¾-in. iron pipe 10 ft. long and painted in alternate black and white 1-ft. marks, corresponding to the graduations of the dredging tide gages. Then

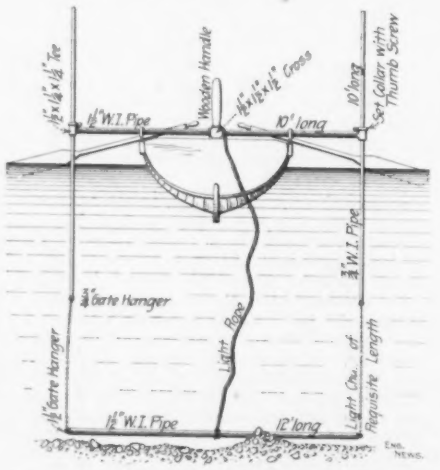


Fig. 2. Submerged Sweep Used with Rowboat.

gage rods could be clamped at any point by set collars and thumb-screws. To the bottom of each rod was attached a light chain, connected at the bottom to a sweeping bar made of 1½-in. iron pipe, 12 ft. long. A light line was attached to the middle of this sweep for convenience in handling it. This sweep was used by laying the upper guide bar in the after rowlocks of the boat. In use, the gage bars were first set to correspond to the tide height indicated on the tide gage, and the boat was then allowed to drift along the channel, being kept on the line of channel ranges by the oarsmen.

In clearing the channel in the Delaware River, the contractor devised a combined diving, sweeping and derrick scow. This consisted of a small dump-scow fitted with a hoisting engine and derrick, and on the middle pocket of the scow, floored over and housed in, was placed the diving apparatus, the diver entering the water directly through a trap in this floor. At the two corners of the stern of the scow were two small winding drums, carrying 40 ft. of light steel wire rope, and to the ends of these ropes was attached a steel sweeping bar, 1 × 6 ins. and 30 ft. long. Both hawsers mentioned were graduated in white and

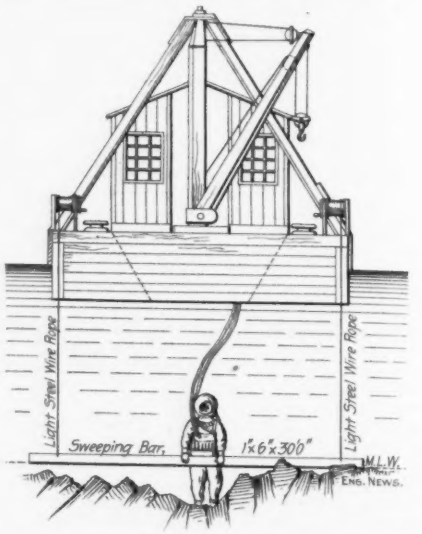


Fig. 3. Sweep and Derrick Scow Used with Diver.

black foot-marks, to correspond to the tide gage. This scow was held in position by four anchors and was moored over the shoal places. With the sweeping bar lowered, the diver descended to the bottom, and, grasping the bar, he walked along the bottom. If he struck an obstruction above the grade line, he stopped and located it. The necessary appliances were then lowered to him and the rock was chained and hoisted. Two divers were used, in six-hour shifts. The work thus done was very satisfactory and the results were positive.

PROPOSED FILTRATION OF THE WATER SUPPLY OF ST. LOUIS, MO.

A plan for the filtration of the St. Louis water supply has been prepared by Mr. Edward Flad, M. Am. Soc. C. E., Water Commissioner of St. Louis, and a municipal ordinance providing for carrying the plan into effect was submitted on April 16 to the Board of Public Improvements. No action having been taken upon the ordinance by the Water Committee, Mr. Flad on June 16 presented a statement to the Board, describing the proposed plan and the reasons why prompt action upon it is desirable. We print this statement, as follows:

The system of clarification contemplated by this ordinance, to-wit, sedimentation with the use of a coagulant followed by filtration through rapid sand filters, is identical with the system at present in successful operation on waters taken from the Mississippi, Missouri and Ohio rivers at East St. Louis, Ill.; Kansas City, Kan.; St. Joseph, Mo., and Cairo, Ill. The capacity of the filter plants at the above locations is approximately 9,000,000, 6,000,000, 7,000,000 and 3,000,000 gallons, respectively, per day of 24 hours. Numerous other small cities have for the past 10 or 15 years been using the same type of filter. A 32,000,000-gallon plant on this system is under construction and almost completed at Little Falls, N. J. The cities of Louisville, Cincinnati and New Orleans, after extensive experiments, have practically adopted the same system. The plant at Louisville, having an immediate capacity of 37,500,000 gallons and designed for an ultimate capacity of 75,000,000 gallons, is at present under construction. A number of smaller filters of this same type have for many years been in successful operation in this city, filtering the water from the Mississippi River. One of these plants has a capacity of 4,000,000 gallons per 24 hours.

It is evident therefore that the system of clarification provided for in the ordinance herewith is no longer in the experiment stage. It is true that a plant designed for the city of St. Louis would probably differ in certain details and in the size of the unit filter from any plant heretofore in use. The same may be said of the filter plant at present under construction at Louisville, and yet Louisville has not hesitated to undertake the construction of a complete plant for filtering all of the water used by that city.

The Board of Public Improvements has heretofore recommended that a series of exhaustive experiments be made before attempting to decide upon the details of the purification plant to be adopted by the city of St. Louis. Recent developments and tests at other locations where the conditions as to quality of water supply are similar to ours, notably the experiments at New Orleans, have shed additional light upon the subject, leaving no room for doubt that a filter plant designed along the lines proposed would satisfactorily clarify and purify our water supply at a reasonable cost.

A series of experiments extending over a period of perhaps eight months and including the operation of a full-size unit of the proposed plant would no doubt furnish additional information which would be of value in designing a plant for the city of St. Louis; but the advantage to be gained thereby would not compensate for the delay. With prompt action a filter plant could be constructed in time to furnish clear water at the opening of the World's Fair in 1904. In my opinion the necessity of having clear water during the World's Fair period is such as to warrant the immediate construction of a filter plant without waiting for further experiments.

The proposed form of ordinance does not attempt to specify in detail the design of the filter, but only the general system, leaving the details to be decided later by the Board of Public Improvements. Under the ordinance as proposed the plant could be constructed in accordance with plans prepared during the past year by the water department, as illustrated in the last annual report of the water commissioner; or according to the plans furnished by the commission of hydraulic engineers in their recent report to Mayor Wells, said plans having been recommended by Messrs. Allen Hazen and George R. Fuller for adoption by the city; or, in order to remove every element of doubt, the plans could be made to follow closely the details used in one of the other cities where this system of clarification is in successful operation.

The cost of the filter plant, with accessories, is estimated not to exceed $1,700,000, and the cost of operation, exclusive of interest and sinking fund charges, is estimated at $140,000 to $180,000 per year (according to the amount of coagulant required) on our present average consumption of 67,000,000 gallons per 24 hours.

Reference to committee on water department is requested. Respectfully,

Edward Flad,
Water Commissioner.

(The ordinance submitted with the statement follows:)

An ordinance establishing a plant for the clarification and purification of the water supply of the city of St. Louis at the Chain of Rocks and authorizing and directing the Board of Public Improvements to construct and erect a filter plant, with accessories and appurtenances, and to make the necessary alterations in the settling basins and connections to same, and appropriating money to pay the cost thereof.

Be it ordained by the Municipal Assembly of the city of St. Louis, as follows:

Section 1. A plant for the clarification and purification of the water supply of the city of St. Louis, with all necessary coagulation basins, pipes and conduits, buildings, pumps, boilers, machinery and appurtenances is hereby established and located at the Chain of Rocks.

Sec. 2. The design for the plant shall be predicated upon:

1. Plain sedimentation, the present settling basins.
2. Sedimentation with the use of a coagulant, either in a portion of the present settling basins or in additional coagulating basins to be constructed hereafter.
3. Filtration of the water thus clarified, through rapid sand filters of the type commonly known as "mechanical" or "American filter."
4. The covering of the reservoirs in which the filtered water is to be stored.

Sec. 3. The Board of Public Improvements is hereby authorized and directed to construct at the Chain of Rocks a filter plant having a nominal capacity of 120,000,000 gallons per 24 hours, together with necessary valves, pipes, conduits, buildings, pumps, boilers, machinery and appurtenances and to make the necessary alterations in the settling basins and connections to same.

Sec. 4. The cost of the above filter plant and alterations in settling basins and connections shall be paid by the city of St. Louis, and for that purpose there is hereby set apart and appropriated out of the fund for clarifying and purifying the water supply the sum of one million seven hundred thousand dollars ($1,700,000).

Sec. 5. There is hereby set apart and appropriated out of water-works revenue to fund for clarifying and purifying the water supply the sum of $1,700,000.

The objections raised by members of the Water Committee to the plan proposed by Mr. Flad are as follows: (1) It is an experiment; (2) that the coagulant used and once dissolved in the water could not be entirely removed; (3) that mechanical filtration methods proposed are patented and are controlled by a trust.

Mr. Flad answers that the use of a coagulant could be avoided by using slow process sand filters; but these would be large and too expensive at the present time. Further, the fear expressed in objection No. 2 is groundless, as the alum used as a coagulant is decomposed by the carbonates of lime and magnesia in the water forming soluble sulphates and aluminum hydrate. A small amount of this latter will remain in the clarified water, but is entirely removed in the process of filtration. For three years past the water at Kansas City has been clarified by this process, and it is wholly satisfactory to the users. That the plan is not experimental is shown in the statement above, and successful plants are now in operation in East St. Louis, St. Joseph and other cities. Finally, says Mr. Flad, the patents have expired on the devices recommended, and Louisville is proposing to use them without paying royalty.

A DUTCH-GERMAN CABLE is proposed under a treaty concluded in July, 1901. A German-Dutch company is to lay a cable from Menado, in the Northern Celebes, to one of the Mariana Islands and to Shanghai. This cable would connect at Guam with the proposed American cable. The Dutch government also obligates itself to lay a cable between Menado and Balik Papan in Borneo. These new lines would give to Germany and Holland independent cable connections by way of San Francisco.

THE EAST INDIAN ENGINEERS, engaged on public work, justly complain of the long delay in the execution of works in their charge, resulting from a government regulation. This rule forbids them to directly order goods required from either the British manufacturers or their agents in India. All articles needed must be ordered through the Secretary of State; and the original reason for this rule was the employment of a number of officials attached to the Indian Office who were supposed to inspect all articles before shipment. As a result, weeks and months of time are lost in this antiquated process, says the London "Architect."

THE CHEAPNESS OF LABOR IN BURMA is shown in a late building note in the "Indian and Eastern Engineer." A Burmese bishop was lately cremated at Mandalay, and a pious ruby merchant paid for the erection of a funeral pyre for this purpose. As shown in a photograph this is a very ornate structure with towers and elaborate panel work, 114 ft. high and 90 × 75 ft., on the base. The pyre is built of bamboo framing, covered entirely with paper work, gilded and painted. It cost the ruby merchant, $665. Unfortunately the photograph is so bad that it can not be reproduced, and it is impossible to show what is really a most creditable piece of architectural work—in appearances at least.

THE NEW GENERATING PLANTS OF THE NIAGARA FALLS POWER CO.*

By H. W. Buck, Assoc. M. Am. Inst. Elec. E.†

The growth of the applications of Niagara Falls power has been so rapid since the starting up of the first power house‡ in 1895 that the entire 50,000 HP. of the first plant has been taken up to its limit. This growth was anticipated by the company three years ago, when the hydraulic development of a second plant was started under way. This plant is nearly completed, and within a few months the first generator of its equipment will be performing useful work.

This power house, from a popular standpoint, may be considered a duplicate of the old one, with which every engineer is familiar, and differs only in some of its technical details. It is located on the opposite side of the intake canal and nearer to the river, and has its water wheels placed at the bottom of its own separate wheel pit. Discharge water is led out from this pit by a branch tunnel, which, after leading independently for about 600 ft., joins the main tunnel, which, as is known, has a capacity of 100,000 HP. The new turbines are somewhat different from those in power house No. 1,§ being of the internal discharge type and having the discharge water carried off through draft tubes, which add about 10% to the effective head. This increase in efficiency gives 10% more power for the same amount of water used in power house No. 1, and in consequence the plant is laid out for 11 units of 5,000 HP. each, instead of 10. The turbines were designed by Escher, Wyss & Co., of Zürich, Switzerland, and were built by the I. P. Morris Co., of Philadelphia. The governors were also designed by Escher, Wyss & Co., and are being built by A. Falkenau, of Philadelphia. They are of the oil pump operated type, and give a maximum variation of speed of about 5%, with 100% load variation, and for fractional changes in load the regulation obtained is about the same as that of a good steam engine.

The electrical equipment is furnished throughout by the General Electric Co. In general, its characteristics are the same as in the apparatus in power house No. 1. The generators are of 5,000 HP. each (3,750 K-W.), wound for 2,300 volts, two-phase, 25 cycles at 250 r. p. m. This type was decided upon on account of its exact interchangeability with power house No. 1. It was considered that the advantages which might result from winding the new generators for a higher voltage would be more than offset by the lack of interchangeability between two power houses located so near together as to be governed by the same conditions.

Electro-technically, power house No. 2 differs in several essential details from the installation in the old plant, the differences being due largely to the advance of the art since the time when the first power house was equipped. The main points of difference are: (1) Closer generator regulation, the regulation on the new machines being 10% and on the old ones about 30%; (2) the entire plant will be operated from a single switchboard instead of two; (3) the feeders will be protected with automatic oil circuit breakers.

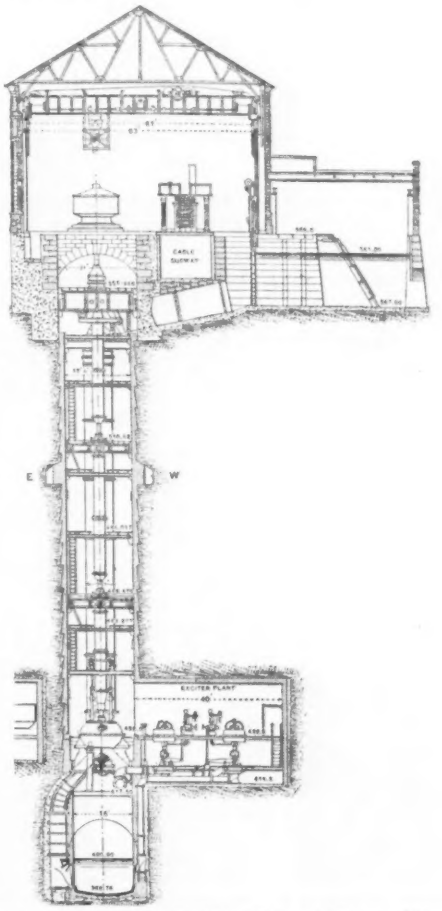


Fig. 1. Transverse Section Through Power House and Wheel Pit, Power House No. 2, Niagara Falls Power Co.

GENERATORS.—The first six generators to be installed will be similar in outline to those in the first plant, being of the external field type, with the nickel-steel revolving magnet ring. This machine is shown in assembly in Fig. 2. In appearance the most striking difference is in the omission of the iron bridges over the machines. This omission results from the collector rings being placed at the bottom of the dynamo shaft instead of the top.

As stated above, the principal difference in these new generators is in the matter of regulation, the regulation being nearly three times as close. This closer regulation was adopted in order to insure constancy of voltage on the system with variations in load and also to reduce to a minimum the unbalancing of the voltages on the different phases caused by difference in loads upon them. These points are of great importance on such a system as that of the Niagara Falls Power Co. Many electrical distribution systems are made up of a very large number of small consumers of power, and the actions of any one customer have little effect upon the voltage of the system; consequently, in such cases regulation is not of such vital importance. But the Niagara Falls system is made up of a comparatively small number of very large consumers of power, any one of whom can, by a change in his load, cause a serious disturbance on the circuits. Furthermore, it is unique in one of its characteristics in

*A paper presented at the annual convention of the American Institute of Electrical Engineers, held at Great Barrington, Mass., June 18-21, 1902.

†Electrical Engineer, Niagara Falls Power Co., Niagara Falls, N. Y.

‡For a description of the plant see Eng. News, May 24, 1894.

§The old turbines were fully illustrated and described in Engineering News of March 30, 1893.

that much of the power is used on large single-phase electric furnaces, which take their power from one phase only. Since it is impossible to control these furnaces so that at all times the same number shall be in operation from each of the two phases, inequality of load on the phases results and the voltages are unbalanced. This unbalancing is disastrous to polyphase synchronous and induction motors on the system, for the high voltage phase tends to carry all the load, and the windings on

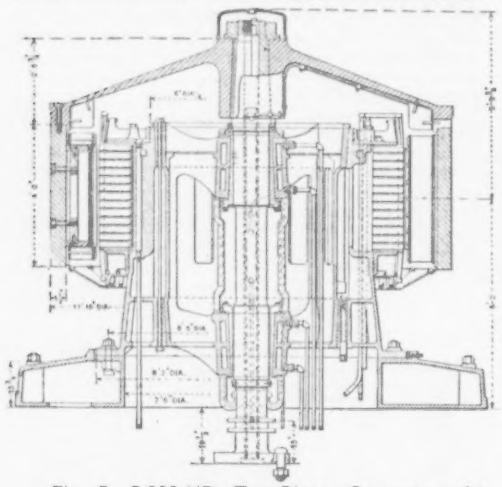


Fig. 2. 5,000-HP. Two-Phase Generator with External Revolving Field. Power House No. 2.

this phase are overloaded. These results can be rendered inappreciable only by the use of generators of close regulation.

The armature winding is a two-circuit series closed winding and consists of formed one-turn coils placed in open slots, with two coils to a slot. The conductor is made up of stranded cable pressed into rectangular shapes. This stranding of the conductor reduces eddy current losses in the armature conductor itself which exist in the case of a large solid bar, as used in the old machines. The open slot is also considered an advantage in a machine of such great length of armature core, for in the closed slot it is necessary to drive the armature bar with its insulation on throughout the length of the slot in order to put it in place. The system used in the new machines of interlacing the end windings gives strong construction to withstand the displacement strains caused by short circuits.

The system of ventilation is radically different in the new machines. Referring to Fig. 2, a baffle plate will be seen between the bottom of the armature winding and the bottom of the revolving field. This forces all the air which is actuated by centrifugal pressure to enter the machine at the bottom inside of the armature shell. From here the air passes outward through the air ducts in the armature core, cooling the iron and the winding. It then continues outward radially between the layers of the field winding into an annular space at the back of the field coils and thence outward through holes in the magnet ring, which are bored in line with the pole piece bolts. The action is that of a centrifugal blower caused by the rotation of the field poles and ring. Some of the air also passes outward at the top of the ring through ventilating holes provided for the purpose. The operation of the air system is very satisfactory, and the blast of air se-

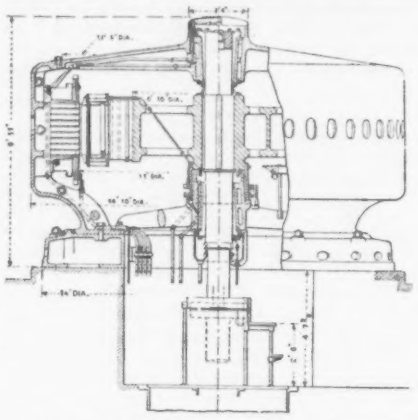


Fig. 3. 5,000-HP. Two-Phase Generator with Internal Revolving Field. Power House No. 2.

cured is tremendous. From tests which have thus far been made, it is believed that these machines will run from 10° to 15° cooler than the old ones. These improvements in design were introduced by Mr. W. L. R. Emmet, of the General Electric Co., with the co-operation of Mr. H. G. Reist.

The generator equipment in this power house is completed with five 5,000-HP. machines of the internal revolving field type shown in Fig. 3. It was decided that the last five machines of the installation should be of this type on account of the much lower cost of building, simplicity of handling and accessibility to the various parts as compared with the external field design. These machines are also wound for 2,300 volts, 25 cycles, two phase and operate at a speed of 250 r. p. m.

These machines will have the same regulation as the first six installed, and in other respects the electrical constants will be the same. From the drawing in Fig. 3 the construction may be clearly seen. It is similar to the standard horizontal shaft engine-driven alternators of well-known types, and its method of ventilation is the same. Recent improvements in mechanical construction of generators have made this type possible at the high speed of 250 r. p. m., and improvements in water-wheel governors have made permissible the lower flywheel effect incident to this design and the consequent omission of the nickel-steel ring of the first machines.

In the two power houses, then, there will be three types of generator, but no trouble is expected in operating all the machines in parallel. As is well known, when two alternators of different regulation operate in parallel, the resultant regulation is the mean between the two. Idle current between the two types may be prevented by careful adjustment of the field currents.

The guaranteed efficiency of the external field generators was:

Full load	98.0%
¾ load	97.3%
½ load	96.0%

From actual test, the full load efficiency has come out 98.15%, which is probably the highest ever attained in an electrical generator.

EXCITER PLANT.—The exciter plant in the new power house will be quite different in arrangement from the old one. The installation will be made complete, with the exciter switchboard in a compartment recessed into the rock at the bottom of the main wheel pit, as shown in Fig. 1. This position will eliminate the long shaft necessary with exciters placed on the main dynamo floor, and will simplify the operation of the plant. The equipment will consist of four 150-K-W. compound wound vertical shaft, 220-volt exciters, each coupled to an independent turbine placed directly underneath. The speed is 750 r. p. m., and each exciter turbine is controlled by a separate governor. The exciter plant wiring diagram is shown in Fig. 4. It will be seen that the power house lights and auxiliary motors will be operated from this plant. A panel is also provided for interconnection with the exciter plant in power house No. 1. The double set of bus bars permits of the separation of exciting circuits and lights and motors. The exciter compartment will be directly connected by telephone with the main generator switchboard.

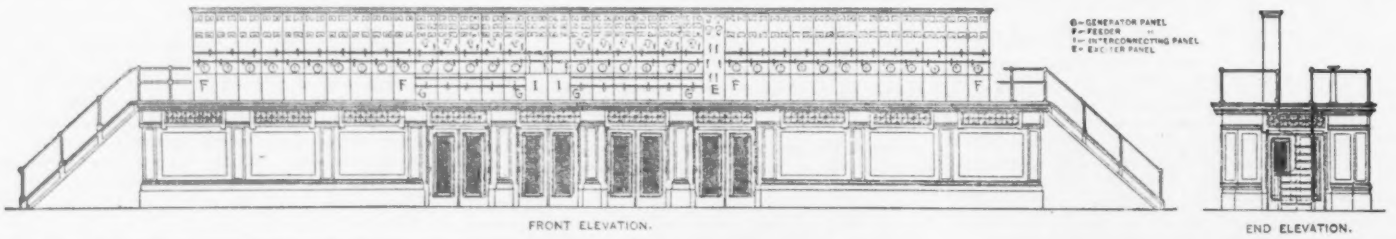
MAIN SWITCHBOARD.—As in all plants, the most important element for successful operation is the layout of the switchboard apparatus. The switchboard in power house No. 2 has been carefully considered, and is believed to be convenient and as simple as it can be made and still accomplish the desired results. There has been a tendency in the design of some of the recent large switchboards toward complexity and the installation of unessential appliances, which by their presence cause more trouble and confusion per se than they are intended to prevent. This has been avoided as far as possible in the design of this board.

Fig. 5 shows a plan of the power house floor and the relative positions of generators, switchboard gallery, oil switches and cable subway. Fig. 5 also shows a front elevation of the main switchboard gallery and controlling panels. The power house is divided in respect to switching into two parts, one of six generators and one of five. Each part has its own group of oil switches and its double set of bus bars. All the switches in the new power house are the General Electric electrically operated oil break type of the well-known design. This switch is shown in Fig 6. All cables are led through the cable subway. They are heavily insulated with rubber, covered with a fireproof braid and supported on brackets with porcelain clamp insulators.

The main switchboard consists of a gallery in the center of the building, having mounted on it 36 separate controlling panels—11 generator, 22 feeder, 2 interconnecting and 1 exciter panel. The relative location of these panels can be seen in Fig. 5, together with their equipment. All the switching is done on these panels by means of relay switches placed in distinctive relation to one another and in such a relation to imitation bus bars placed throughout the face of the switchboard that the connections are clearly indicated and no mistake in switching can easily be made. On the generator panels are two selector relay switches and one generator relay switch; on the feeder panels are two relay selector switches, and on the interconnecting panels are relay interconnecting switches for making the various connections between the two groups in the new power house and between the two power houses. On the sub-bases of the generator panels are dummy exciter bus bars, with relay double-throw generator field switches. All these relay switches operate electrically the real switches out on the power house floor, and have the exact relation to the dummy bus bars which the real switches have to the real bus bars, so that even a green man could hardly make a mistake in throwing a switch. Return indicators are placed adjacent to the relay switches, so that the operator may tell at once whether the real switch has responded correctly to the movement of the relay.

There has been a considerable craze during the last few years for the operation of switchboard apparatus by bench board control, but in designing the board for this plant the bench board system, although carefully considered, was rejected as inconvenient. In the bench board system the operator in switching must first go to the bench board and pick out the relay switch in question, then, taking his eye off the switch, he must pick out from a concentrated mass of instruments in front of him on entirely separate panels the instruments involved in the movement which he is about to make. This is not altogether convenient, and there is always a chance of a mistake. It is believed that the advantages of this bench board system are more imaginary than real.

In the switchboard installed in this plant each panel is a complete unit and comprises all the apparatus, both switches and instruments, which are necessary for any operation which may be made upon it. Thus, when the operator goes to a feeder or a generator panel he has before him, enclosed within the limits of the particular panel, all the apparatus with which he is concerned at the time. All synchronizing will be done by means of a Lincoln synchronizer placed upon a swivel on the top of the switchboard.



Floor Plan of Power House No. 2.

FIG. 5. PLAN OF POWER HOUSE FLOOR AND ELEVATIONS OF MAIN SWITCHBOARD. POWER HOUSE NO. 2.

The generator field rheostats and field switches are located under the main switchboard gallery. All feeders are equipped with recording wattmeters installed in the basement of the new office building, through which the outgoing feeders pass at the end of the cable subway.

It is the intention to operate the 21 generators normally in four independent groups, but the interconnections are so arranged that they may all be operated in parallel if desired, or any one generator may be thrown on any group.

The feeder circuit breakers will be operated by time limit relays having an attachment devised by Mr. W. K. Gibboney, of the Power Co. A time limit relay is a

useful device for preventing a circuit breaker from opening unnecessarily at times of momentary overloads, but if a real short circuit occurs it is objectionable. Experience has shown that on a system like that at Niagara, where there is a large amount of synchronous apparatus in operation, if a short circuit occurs it must be disconnected at once, or else the prolonged drop in voltage will cause all of the synchronous apparatus to drop out of step; whereas, if the short circuit can be disconnected

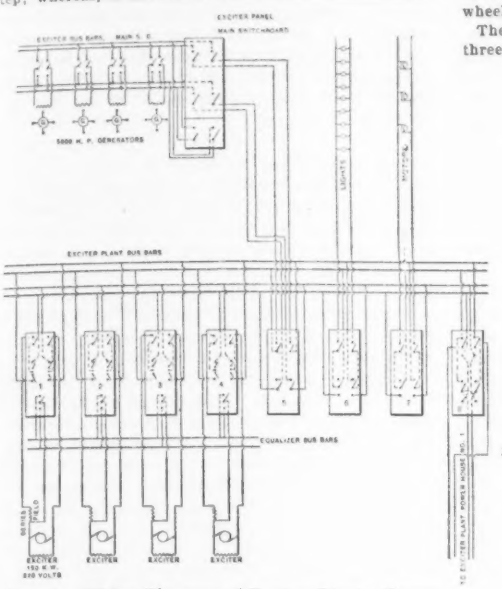


Fig. 4. Wiring Diagram of Exciter Plant. Power House No. 2.

instantly, the inertia of the rotating parts of the synchronous apparatus will keep them in step for this short period. For this reason, the ordinary time limit relay is objectionable, since it causes a delay. The device referred to above consists of a dash pot attachment to the tripping plunger of the circuit breaker. This retards the movement of the plunger and consequently the opening of the breaker for ordinary temporary overloads, but if a real short circuit occurs the pull on the plunger is so strong that the dash pot has no effect and the circuit breaker opens instantly.

THE CANADIAN PLANT.

Anticipating still further increase in the use of Niagara power, the Niagara Fall Power Co. has, through its allied company, the Canadian Niagara Power Co., started work on its plant on the Canadian side of the Falls. This plant will be located in the Victoria Park, about 1,500 ft. above the Horse Shoe Falls. Its hydraulic feature will be similar to the American plants, with its intake canal, wheel pit and discharge tunnel leading to the foot of the Horse Shoe Falls. This power development will be used for the transmission of power to Toronto and other Canadian cities within transmission distance, and for the distribution of power to factories located in Canada in the neighborhood of the power house. It will also be used for the supply of power to the American power system, with which it will be arranged to operate in parallel.

The essential difference embodied in this plant will be in the size of unit and in the electrical arrangements. The unit will be of 10,000 HP. capacity (7,500 K-W.), and the generators will be wound for 12,000 volts three-phase. The frequency will be retained at 25 cycles for the sake of uniformity with the American plants, so as to permit of parallel operation. In selecting this size of unit, the American and Canadian systems were regarded as one. Since this is likely to reach ultimately an output of several hundred thousand horse power, a unit of 10,000 HP. is not a large proportion of the whole, and is not too large an amount of power to concentrate in one machine from the standpoint of convenience.

The principal advantage in a unit of this size over the smaller one is in the reduction in cost of development per horse power. This reduction in cost results from:

(1) Lower cost of generator per horse power.

(2) Lower cost of turbines per horse power.

(3) A 10,000-HP. unit occupies only slightly more space that one of 5,000 HP. capacity, which results, for a given plant output, in great reduction in length of wheel pit, power house and forebay and a consequent reduction in construction.

Other advantages will result, such as simplicity of operation, owing to the reduction in the number of units and reduction in the cost of maintenance. This size of unit was suggested by the engineers of the Niagara Falls Power Co. and was adopted upon their recommendation. The generators, three of which have been ordered, are being constructed by the General Electric Co.

This generator is shown in assembly in Fig. 7. It is of the internal revolving field vertical shaft type. Its revolving field ring is built up of punched laminations, bolted together with joints lapped. This method of construction gives a uniform and definite strength of ring and high magnetic permeability. On account of the high speed, 250 r. p. m., the generator is very small as compared with some of the large engine-driven units, its overall diameter being only about 19 ft. The weight of the revolving part of the machine is 141,000 lbs., with a flywheel effect at 250 r. p. m. of 2,000,000,000.

The generators are wound directly for 12,000 volts three-phase, instead of 2,300 volts two-phase, as in the

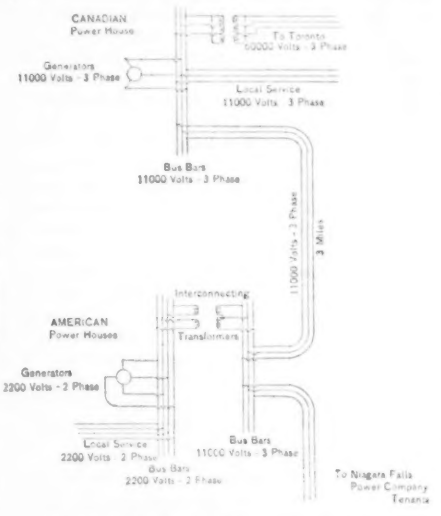


Fig. 8. Method of Interconnecting American and Canadian Generating Plants at Niagara Falls.

American plants. This high voltage was selected, not for long distance transmission, but for economy in distribution to power users near the power house. In distributing large amounts of power underground from a 2,300-volt two-phase plant, after a radius of about one mile is exceeded, it becomes cheaper to transform to 12,000 volts three-phase and distribute at this voltage than to supply power directly at 2,300 volts. From this it becomes evident that great economy results from the direct generation of the higher voltage. For long distance transmission, step-up transformers will be used to raise the voltage to 22,000, 40,000 or 60,000 volts.

Fig. 8 shows the method which will be adopted for operating in parallel the American and Canadian systems. The connection will be made by triple conductor cables carried across the upper arch bridge over the Niagara Gorge. The paralleling will be done through step-down Scott connected transformers, as shown.

The switchboard and auxiliaries have not yet been decided upon for this power house. It is not expected that it will be in operation for a year or 18 months.

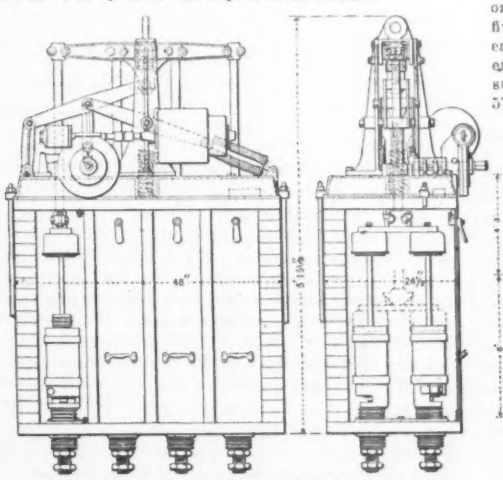


Fig. 6. Electrically-Operated Oil-Break Switch, 2,200-volt, Two-phase. Power House No. 2.

DISCUSSION.

Mr. F. A. C. Perrine asked a number of questions in regard to the paper. He remarked on the change in type of turbines, and asked what provision had been made to take care of the thrust, especially the variation in the thrust which would occur, due to the use of a draft-tube, with varying loads. He called attention to the omission of draft-tubes on the turbines in power house No. 1, and gave it as his impression that these had been omitted on this very account, i. e., because of the difficulty of properly providing for these variations in thrust. He noted that on a recent inspection an engineer with whom he was acquainted had noted that the large turbine shafts in the old plant appeared to run out considerably between bearings, as much as an inch or so, and asked whether anything had been done to remedy this defect in the new plant. He also pointed out that the paper gave the efficiencies of the generators built on the old type, but no figures for the new internal revolving field machines. Mr. Perrine seconded the opinion advanced in the paper that the bench board system of control was not suited to the needs of the present case. He considered that system practicable only in small stations, or where the instruments can be grouped close enough together so that the whole set of instruments is under eye at once from the controlling bench. The advantage claimed for the system, that all the switches were under hand at once, he characterized as largely fictitious. As to the propriety of the omission of recording instruments from the board, he fully agreed with Mr. Buck also. All recording instruments should be placed in the superintendent's office, and nothing placed on the board except what the operator there directly requires for his work, since anything additional is only confusing.

Mr. P. H. Thomas noted that it was proposed to so interconnect the Canadian and American plants that either could supply current to the other, as might be required, and asked whether the question of duty had been considered, whether there would be any customs complication in connection with the importation of power.

President Steinmetz, referring to the proposed transmission of Niagara power to Toronto, asked for details in regard to this transmission. He pointed out that conditions here were much more unfavorable for long distance transmission than in Southern California, and that some modifications of practice there might be expected.

In reply to the various points brought up by these and other speakers, Mr. Buck first took up the matter of the turbines. These are single-wheel turbines, discharging radially inward. The supply casing is spherical (as is shown in Fig. 1, accompanying the paper) and the discharge is axially downward. (As will be seen from the drawing, the draft-tube turns to one side, and passing down along the outside of the pit to the level of the bottom of the discharge tunnel, it opens into the latter from one side.—Ed.) The matter of variation in thrust had been carefully considered by Escher, Wyss & Co., and was thought to be fully provided for. The weight of the shaft, etc., is taken care of by a hydraulic piston at the bottom, and the variations in thrust are taken care of by an oil pressure thrust-bearing above the turbine. The eccentricity in the shafts of the old turbines Mr. Buck explained as only apparent. The shafts are riveted steel-plate cylinders, 38 ins. in diameter, and when, during the revolution of the shaft, the lap of the plates comes around, it gives the impression of an eccentric shaft. As to the new internal field alternators, Mr. Buck stated that their efficiences had not yet been obtained.

Referring to the question of duty on electric power between Canada and the United States, Mr. Buck stated that the matter had been decided by the governments of both countries to the effect that as electricity is imponderable it cannot be subject to duty (!).

The Toronto transmission line will be operated at 40,000 or 60,000 volts. Each transformer would be wound with five coils, two in the primary and five in the secondary, each coil to carry a pressure of 11,000 volts. With different connections of these coils various secondary pressures could be obtained, as 22,000, 33,000, 38,000 and 57,000 volts. The insulators to be used will be of novel

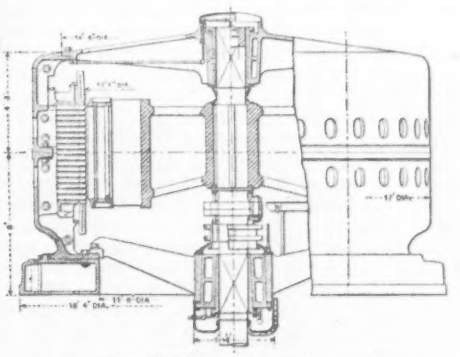


Fig. 7. 10,000-HP. Three-Phase Generator, with Internal Revolving Field. Canadian Niagara Power Co.

construction. The general form is cylindrical, with a horizontal axis. The cylindrical surface has four circumferential grooves and five ridges. One wire would be laid in each groove, and fastened by a tie-wire wound in the groove. The insulator is supported on a yoke by means of pins projecting into the ends of the central opening. This construction of insulator is thought to secure highest insulation and to do away with all trouble from drip. The insulators are to be made in various sizes, from 8 to 14 ins. long.

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

Only a few years ago, when natural gas first came into extensive use as a fuel, there was a general impression that the supply was inexhaustible. No one paid any attention to the warnings of geologists that the porous rocks in which the gas was stored would soon discharge all their contents. Instead, the newspapers gave wide currency to the deliverances of psuedo-scientists, who propounded the comforting theory that the gas was being evolved as fast as it was being used. So the use and waste of the new fuel went merrily on, and the waste was probably greater than the use. It was burned under boilers and for a hundred uses where coal would have answered just as well. It was blown to waste from street torches that burned night and day. In this manner a very few years sufficed to exhaust most of the available deposits of this wonderful fuel. Had it been reserved for domestic use and for the special manufacturing uses in which it possesses large advantages over any other fuel, such as the production of glass and fine pottery, the supply might have been made to serve for a half century or more, and have been of inestimable benefit to mankind. As it was, the crazy speculation which followed the discovery of natural gas in Pennsylvania, Ohio and Indiana, and the losses which resulted from capital invested on the theory that the supply was to be permanent, go far to offset all the benefit that the world realized from its utilization.

Is the world any the wiser for its experience? Does the public have any appreciation of the poverty under which future generations will labor because of our present prodigal waste of the gifts of Nature? We fear the answer must be in the negative.

Even as we write, there lies before us a description of a plant for manufacturing lamp black in West Virginia. Nine natural gas wells have been driven and their production, amounting to 4,000,000 cu. ft. of gas per day, is burned in such a manner as to deposit the carbon in the form of an impalpable soot, which is used for coloring cement mortar. Possibly the product is a trifle finer and better than that which could be produced from the combustion of a coarser fuel; but does it not seem a pity to use up the small remaining stocks of natural gas for such a purpose? Doubtless at present these wells are too far from any centers of population to permit the gas to be used for domestic purposes, or even for a high grade of manufactures; but the growth of population may change all that in a few years.

It seems to us that such incidents as these, or the present object lesson which is being given of the dependence of civilization on coal, must set thoughtful men questioning whether there is not some radical defect in our systems of law.

In our eagerness to defend the liberty of the individual and the rights of private property, have we not overlooked the larger rights of Society as a whole? Is the plan so long followed of turning over the gifts of Nature as private property to the first one who seizes possession of them necessarily the best for our present civilization, even if it was best when population was sparse and customs and laws were crude?

A free public bathing establishment may not be as conspicuous or enduring a monument as a granite shaft, but in the majority of cases the former would doubtless prove to be of far greater benefit to a community. Such at least was the opinion of a philanthropic citizen of Fonda, N. Y., who, some six years ago, chose this plan of commemorating a kinsman. The Campbell Bath, as it is called, is an open swimming tank, lined with masonry, having a water surface of about 2,000 sq. ft., surrounded by a neat wooden building containing dressing rooms and a single private bathroom and bathtub. Water is supplied from an artesian well, equipped with a power pump, and also by the village water-works when water from the latter can be spared. The bathing establishment cost $3,000, besides which the donor has given enough money as an endowment to pay the moderate expenses of an attendant and of free bathing suits and towels. The bath is closed on Sunday, except to those who can use it at no other time. The bath and endowment fund are vested in the Fonda Improvement Society, which was incorporated for the purpose.

Institutions of this sort, whether created and maintained at private or public expense, are of great value to a community. At the Brookline public bath, which includes a swimming pool, school children are given free instruction in swimming, a practice which might well be adopted elsewhere. Public bathing establishments in the United States are at present few in number, but present indications are that in the next few years their numbers will be multiplied many times.

The question of the appearance of exposed concrete is coming to be of particular importance with the great development in the use of concrete in situations where a pleasing appearance is desirable. In a very large majority of cases, concrete structures are disfigured by a lack of uniformity in color, dark or light patches being frequently noticeable, while in other cases a streaky appearance is to be seen. In discussing the subject recently with different engineers experienced in this class of work, there was a general admission as to the patchy appearance, and also an admission of inability to say what is the cause or how a uniform color and appearance can be obtained on concrete structures. Even where there seems to be no criticism to make as to the mixing and placing of the concrete, and where the surface is a smooth mortar surface without plastering, the unsightly appearance prevails. In one particular case an attempt was made to get a uniform tint by washing the exposed surface with Lafarge cement dissolved in water, making a wash of about the consistency of ordinary whitewash. This helped the appearance somewhat, but was not an entire success. It is thought by some engineers that the best appearance of concrete surfaces can probably be secured by plastering them with mortar, but this remedy is frequently worse than the disease, as the plastering is very apt to crack and scale off or become defaced, with the result that the appearance will probably be worse than that of the plain concrete. The use of plastering in this way is therefore generally opposed, it being considered better to require a full smooth mortar surface, the mortar being a part of the body of the concrete, with the stone in the concrete worked back so as not to be exposed.

One suggestion that has been made is that concrete structures usually have large areas of flat surfaces, on which patches or blemishes are much more conspicuous than they would be if the surface were relieved by the roughening or irregularity which is common in stone work, and this may well be borne in mind by designers of concrete structures. It has been said that differences in the cement used affect the color, but it has also been found that patches appear even where care has been taken to use the same cement and a uniform mixture. It is not at all probable that the problem is incapable of solution, and it will certainly receive much more attention as the use of concrete increases for structures of architectural and artistic importance. On structures of this kind additional expense incurred in eliminating the trouble in question will be fully warranted, but up to the present time few engineers have gone very thoroughly into the matter, as they have usually been limited to the consideration of providing strength and durability at the least cost.

We shall be very glad to receive contributions from any of our readers who can furnish information as to how these difficulties may be remedied, and we venture the suggestion that the subject might well be experimentally investigated in connection with theses work in some of the engineering schools having well equipped cement laboratories.

It is a significant fact that when the Mayor of Boston recently wished to have some one undertake the study of the population and finances of the city, which is noticed elsewhere in this issue, he turned to the engineering department as being the best fitted to carry out the work. But in most American cities, where else could a Mayor turn to have work of this sort done? In Boston, it is true, the work might have been given to the statistics department, which, indeed, gave much assistance in the work. But Boston is the only city in the United States which now has such a department.

This instance is but one of many recent occurrences going to show that engineers are gradually being recognized by the higher elective officers of American cities as something more than surveyors. As a matter of fact, in most cities the engineering department is the only approach to a permanently organized bureau officered by men trained for the scientific solution of municipal problems.

The New York Sinking Fund Commissioners have acted wisely in ordering all fire insurance policies on city buildings cancelled and forbidding further insurance on buildings owned by the city. Their example might well be followed by all cities of any size, and by most of the larger corporations as well.

That there should be opposition to such a course merely shows what crude ideas many people hold on the subject of insurance. It appears to be thought that insurance wholly wipes out the loss by fire. The fact is, of course, that it merely distributes this loss among a large number. If a city or a corporation or a firm, or even a private person has so large an amount of scattered property at risk that it or he can afford to stand any loss which may occur, then it is bad policy to insure such risks. If such a city or company does obtain insurance, it must in the long run stand not only all its losses, but in addition a percentage of this sum representing the expense

of carrying on the insurance companies' business, with their profits, and the commissions of the brokers.

Probably this simple and elementary fact would be better understood were it not for the aforesaid brokers. The bigger the company or the city which has risks at stake, the greater the profit which the brokers lose if the risks are cancelled. They can find any number of specious reasons why insurance should be continued, and too often, it is to be feared, other more tangible arguments are used. It is not many years ago that one of the principal railway companies in the Northwest, with a system thousands of miles in extent, was discovered to be carrying heavy insurance on all its combustible property, the commissions on which had made wealthy a firm of brokers closely associated with the management

It is hardly necessary to add that we do not argue at all against insurance in its legitimate field. What we wish to point out is that the insured party has in the long run to stand his losses by fire anyway, and where his interests are large enough and diversified enough to enable him to endure the immediate effect of any particular loss, insurance is worse than useless to him.

As an example of the specious arguments used by the brokers, we note the following quotation in a New York daily paper from a firm of insurance brokers which was hit by the order cancelling policies on municipal property:

> We have statistics from over 100 of the prominent American cities regarding city property insured, and we learn that over 90% of them protect nearly all of their property by policies.
>
> From the reports which we have received, we feel justified in the statement that during the past 10 years the city has lost by fire to public property more than the insurance premiums paid in for 25 years.

If the first of the above paragraphs is true there is evidently need for a general reform in the conduct of this branch of municipal affairs

If the last of the above paragraphs is true, it is a fair inquiry how long the insurance companies could continue to do business on such a basis.

THE DECISION OF CONGRESS IN FAVOR OF THE PANAMA ROUTE FOR AN ISTHMIAN CANAL.

As the newspapers have already announced, Congress has followed the advice of the Isthmian Canal Commission and selected the Panama route for a Central American canal. The bill, as passed by the Senate on June 19, was adopted by the House on June 26, the advocates of Nicaragua nearly all joining in the final vote because they appreciated that further insistence on the Nicaragua route would only result in preventing any canal legislation at the present session of Congress.

This final result must be regarded as a victory for sound statesmanship, and particularly for the policy of following expert advice in legislative matters where experts are best fitted to decide. The Isthmian Canal Commission was undoubtedly more competent to judge which was the more advantageous of the two canal routes for the United States to adopt than was Congress itself; and Congress has done wisely in acting according to the advice of the commission.

We can say this with the greater freedom since we have frequently pointed out in these columns that the extremist advocates of each route were about equally in the wrong, and that the advantages were by no means all on the side of Panama. More or less disappointment at the result will doubtless be felt on the Pacific Coast and in the South, where the shorter distance via the Nicaragua route between Atlantic and Pacific ports of the United States has taken a strong hold on the popular mind. This difference in distance, however, will be to a large degree offset by the shorter time required for passage at Panama, and the disappointment that Nicaragua was not selected will doubtless soon disappear in the gratification that a canal is actually to be built.

Another thing which may well be said is that the Nicaragua route, as laid out by the Isthmian Canal Commisssion, is far less attractive than was the old Menocal route for a Nicaragua Canal, as planned by the Maritime Canal Co., a dozen years ago. That route, with its large open basins, its small proportion of actual canal prism, and its very moderate estimate of cost—little more than a third of the present commission's estimate for a Nicaragua Canal—took strong hold on the imaginations of capitalists and engineers, especially in those sections of the country where the construction of the canal is a vital political issue.

Engineers now know, of course, the numerous dangers and difficulties in connection with the plans of the old Maritime Canal Co.; and we can all look back now and see how fortunate it was that no greater amount of capital was sunk in their work, and that the government did not undertake to finance the project, as it came so near doing at one time. That Congress did not fall into that error was due, without doubt, to the sound judgment and unswerving honesty of the commission of engineers, made up of the late Gen. Ludlow, Admiral Endicott and Mr. Alfred Noble, which first investigated the Menocal plan.

Following this came the much more complete investigation made by the Nicaragua Commission of 1897-99, and then the still more thorough work of the present Isthmian Canal Commission. It may safely be assumed that the route laid out by the latter was the best that could be selected at the present time for a Nicaraguan ship canal of the size that modern commerce demands. This route, however, involves so much curvature, such a long distance of contracted prism, so many works of great size, and finally such a large total cost, that it contrasts most unfavorably with the present Panama route in its physical characteristics.

We have said above that Congress has decided upon the Panama route. There is still the bare possibility that either the New Panama Canal Co. or the unstable Columbian Government may fail to give the United States a satisfactory title, in which case the President is to undertake the work at Nicaragua instead. This possibility, however, is doubtless very remote; and we may confidently look forward, now that the responsibility is placed on the Executive Department, to rapid progress toward the actual undertaking of the Panama work.

A most fortunate feature of the act, as passed by Congress, is the provision for placing the entire conduct of the work in the hands of a commission of seven, at least four of whom are to be "skilled in the science of engineering," and at least one is to be an army officer and one an officer in the navy.

As our readers will recall, we have repeatedly urged that the work of constructing the canal should be placed in charge of an engineering commission; and in our opinion no feature of the act is deserving of greater praise.

With such a commisssion in charge of the work as President Roosevelt can be relied upon to select, the country can be assured that the work will be conducted in an efficient, economical and honest manner.

LETTERS TO THE EDITOR.

Mosquito Extermination.

Sir: Your editorial and review of Reports on Mosquito Extermination in your issue of June 19 were extremely interesting and gratifying. It has been a long struggle to get a public hearing of what I knew to be a practical movement, viz.: To engineer the mosquito out of existence as a serious menace to public comfort, to property values, to the healthfulness of large sections and consequently to the general economic betterment of millions of our population.

Of course incredulity prevails largely still even among persons of intelligence, but it is gradually disappearing under the co-operation being given by such discriminating and powerful publications as Engineering News, The Century Magazine, and others—the latter even modifying its arrangement of articles for this year in order to make timely space in its July number for a condensed article on the successful work of extermination on Cutter Island, Oyster Bay harbor, last summer.

You very truthfully say that engineers generally can keep in the reform. In examining different sections of the country I find many instances where engineering works have greatly increased the dangers from mosquito breeding. This has resulted from a lack of knowledge of the life history of the pest on the part of engineers and of their disregard of necessary but unthought-of precautions. There will doubtless be less of these mistakes in the future; indeed, to avoid them becomes as much an engineer's duty as to see that life and health are secured from accident through faulty construction. Very truly,

Henry Clay Weeks.

Bayside, L. I., June 21, 1902

Transition Curves as Used on the Canadian Pacific Ry. Mountain Division.

Sir: The writer is not prompted in sending this communication on account of the lack of literature on the theory of the transition curve, but by the lack of practical knowledge of this simple matter among field engineers. The few simple facts required by the field engineer are, in most books published on the subject, so covered up and smothered among theory and equations involving unknown qualities up to the thirteenth power, etc., that he who does not understand calculus, both differential and integral, loses sight of them entirely. As a sequel to the criticism of the Engineering News on "The Transition Curve" by Crandall (at the time of issue), the writer asked a recent graduate of Cornell University if he could take out deflections for a transition curve from Crandall's table, the reply was: "No, but Crandall can." There is where the trouble lies; all our field engineers are not Crandalls, and books to be of use to them must be so written that they can be undersood.

The "Transition Curves" (or spirals, for short) described by most writers are identical and have the following properties in general:

(1) The spiral is twice the length of the simple curve which it replaces.

(2) The angle of the spiral equals the angle of the simple curve which it replaces.

(3) The curvature of the spiral increases directly as the distance from the beginning of same.

(4) The offsets from tangent and from the circular curve produced vary as the cube of the distances (nearly so, not as fast as the distance measured on the spiral and faster than the distances measured on the tangent, but very close to the cube of the long chord).

(5) The deflection from the beginning of the spiral varies as the square of the distance measured on the spiral, and, the deflection for the end of the spiral equals one-third of the angle of the spiral. To turn tangent at end of spiral, deflect from beginning of spiral two-thirds of the angle. (This is true for spirals of ordinary length, but where spirals exceed 400 or 500 ft. or the angle becomes large when a spiral of rapid rate of increase of curvature is used, a much better alinement will be had by moving up the transit than by applying corrections suggested by some writers.)

Now, the above are the plain facts required in the field without the theory or proofs, and it is to be hoped that the editor, in his pruning, will not suppress them as being so self evident that they are thoroughly understood by all field engineers and instrument men.

We come now to where the discussion begins, namely, the method to be followed in making up the deflection tables. Crandall divides all spirals into 20 equal parts, and then, by multiplying one-third of the spiral angle by coefficients given, the deflection may be obtained from both ends and from three intermediate points to each of the other 20 points. The corrections given are of no practical use in the field, as the instrument should be moved up before the angle becomes so great that a correction is necessary.

Mr. A. C. Dennis, Divisional Engineer, C. P. Ry., Winnipeg, in his instructions to his engineers, says: "For deflection angles divide the spiral angle by 48, multiply the quotient by 1, 4, 9 and 16 for points going on the spiral and by 11, 20, 27 and 32 for points going off.

This is a very simple method and similar to Professor Crandall's.

F. K. Vail's method (Engineering News, Sept. 20, 1900) is practically on the same plan, namely, deflection found by the use of coefficients.

The above, and several other methods of a similar nature, are recommended by the fact that they are directly applicable to any length of spiral for any degree of curve, but the simpler method of having tables constructed from which deflections, shifts, long chords and tangent distances can be taken at once for the common curves (which cover 99 cases out of 100) will appeal to the engineer in the field.* This method was described by Mr. E. Holbrook (Engineering News, June 13, 1901), and was enlarged and commented on very ably by Messrs. W. C. Armstrong and W. H. Sadler, in Engineering News of Aug. 15, 1901.

In 1894 the writer was given copies of seven of the 17 tables inclosed, by Mr. M. W. Ensign (then Chief Engineer of the B. A. & P. Ry.). No instructions accompanied the same, only a few minutes verbal instructions being necessary. The author of the form of these tables will certainly be honored and respected by all field engineers into whose hands they may fall. The method is certainly Mr. Holbrook's more fully developed.

It may be said in addition to directions in the instructions (reprinted below—Ed.) that the blank spaces in the

*The writer refers to the engineer in the field office, who prepares the data for the transitman.

"Tables of Deflections" denote the position of the transit, and the deflection angles to all other points may be found on the same horizontal line to the left and right of the blank space, as the points are back or in front of transit going on spiral. Thus, in the example given: 66', 24', 54' and 1° 36' are found in the first line, page 6, in columns 2, 4, 6 and 8 respectively. Then the transit moved to 8, the back-sight deflection 3° 12' is found on line 8, in column 0, the deflections 1° 18' and 2° 1½' are found on the same line in columns 10 and 11. Then the transit moxes to 11 (P. C.), the back sight 2° 15' is found on line 11 in column 8 (the last transit point); turning vernier to zero to get common tangent at P. C., with transit at P. S'., deflections 1° 33', 2° 54', 4° 03', 5°, 5° 45' and 6° 03' are found on line 11 in columns 9, 7, 5, 3, 1 and 0 (note columns 1 and 3 of this table have been omitted in revising table), it will be noted that vernier reads zero on common tangent of P. S'.

The formula for deflection in minutes $= \frac{N^2 L}{10}$ may not be plain to all.

L = length of subchords = distance on spiral of change of 1° in the degree of curvature.
N = number of subchords from transit to point being set.

The distance from P. S. to any point on spiral = N L (N may be fractional). From (1). Length of curve replaced by spiral $N L = \frac{N L}{2}$, therefore, $\Delta^\circ = \frac{N L D'}{2 \times 100}$. From definition of L, D' at point N L = N. From (5). Deflection = $\frac{1}{6} \Delta$, therefore, substituting N for D' and multiplying by 60 to reduce to minutes,

$$\frac{1}{6} \Delta = \frac{N^2 L 60}{3 \times 2 \times 100} = \frac{N^2 L}{10}. \qquad (6).$$

As shown in instructions, N becomes a fractional number when it is necessary to spiral a curve containing odd minutes; this, however, may be changed if desired, and in staking out trestles on spirals it may be more convenient to use the following: As above, N L = d = distance from P. S. to point being set, multiplying (6) by $\frac{L}{L}$, deflection in minutes $= \frac{N^2 L}{10} \times \frac{L}{L} = \frac{(NL)^2}{10 L} = \frac{d^2}{10 L}$. (7).

That is, the deflection in minutes for any point on spiral equals the distance to the point in feet squared, divided by 10 times the length of the subchord. As can be readily seen by formula $\frac{N^2 L}{10}$ (6), the deflection for any point of the spiral depends directly on L. If L be chosen once, twice, three times, etc., the length of the L given in a particular table, then the deflection can be readily taken from that table either by multiplying the deflections under corresponding numbers by the ratio, or dividing the deflections under the corresponding distances by the same ratio.

Example (8). It is desired to spiral a 3° 40' degree curve, using a 75-ft. subchord.

$$N = 3\tfrac{2}{3}, \quad \frac{N^2 L}{10} = 1° \ 40'/_0'.$$

But suppose that no tables were constructed for the 75-ft. subchord. Turning to the table for 25-ft. chords the deflections for points 1, 2 and 3 are 02½', 10' and 22½', multiplied by 3 gives, 7½', 30', and 1° 7½', or, the deflection for equal distances, columns 3, 6 and 9 are 22½', 1° 30', and 3° 22½', divided by 3 gives 7½', 30' and 1° 7½', same as will be found in the table of the 75-ft. chord. Now, by using the latter method in this example, points may be set every 25 ft. by dividing deflection given, for L = 25 ft., by 3. The length of spiral is 275 ft. or 11 25-ft. subchords; under column 11 is 5° 02½', divided by 3 gives, as by formula, 1° 40 $^1/_0$', then, to run spiral from P. S'. divide the deflections 1° 20', 2° 35', etc., to 10° 05' (found on line 11) by 3, and the result will be the deflections for every 25 ft. of a 75-ft. subchord spiral.

It will be further noticed that in spirals of equal length, S is also nearly proportion to L. Example:

S for 12° curve, 25' subchords = 7.82';
S for 4° curve, 75' subchords = 2.62'.

In the tables wherever there is a subchord half the length of another subchord, the former table can be used for all degrees of curves differing by 30'.

Example 9: For 4° 30' curve using 50-ft. subchord, use 9 25-ft. subchords using ratio of 2 as explained in example (8).

The table for 15-ft. subchords can be used instead of the table for 60-ft. subchords and spirals put in for curves varying only by 15'.

If it desired to use an 80-ft., 90-ft., 100-ft., 120-ft. or 150-ft. subchord use tables for 40-ft., 45-ft., 50-ft., 60-ft. and 75-ft. subchords respectively, using ratio 2 as described in example (8).

If it is desired to use an 82½-ft., 90-ft., 97½-ft., 105-ft., 112½-ft., 120-ft., or 135-ft. subchords, use tables for 27½-ft., 30-ft., 32½-ft., 35-ft., 37½-ft., 40-ft. and 45-ft. subchord respectively, using ratio of 3.

It is hoped that these examples will give some idea of the great flexibility of each single table; in fact, the plan of making one table of 10-ft. subchords extending to a 50° curve might be as convenient as the present form.

In cases not covered by tables, the two important items, namely: the shift, S, and the distance to be added to semi-tangent, C, can be found from the following formula:

$$S = \frac{R' \text{ Vers } \Delta}{3} \text{ (approximately).}$$

C = ½ L N Cos ½ Δ (approximately).
L = length of spiral divided by D'.

Deflection in minutes for points up to D' less odd minutes are: $\frac{L}{10}, \frac{4 L}{10}, \frac{9 L}{10}, \frac{16 L}{10}$, etc. It is not necessary to figure deflection for end of spiral, but take same direct from (5) = ½ Δ. Then, to run spiral from other end, figure deflections for D' for distances L, 2 L, 3 L, 4 L, etc., and subtract $\frac{L}{10}, \frac{4 L}{10}, \frac{9 L}{10}, \frac{16 L}{10}$, etc., respectively.

Deflection for P. S. = ⅔ Δ. (From (5).) This is not an improvement over other methods that have been advanced, but it is certainly as practical and as easy as any the writer has ever seen, excepting the one proposed by Mr. A. C. Dennis, and shows that the method can be made general.

The introduction of the long chord in the tables is very convenient in making first location in heavily timbered country, only the line of this chord need be cut out, stakes at station points can be set by offsets from this line.

The introduction of D, the degree of the curve whose radius R = R' + S, enables the engineer in the field to take out tangent from the tables of tangents of a 1° curve.

The construction of "Deflection Tables" entails very little work, from (6), $\frac{N^2 L}{10}$ it is readily seen that the first deflection in minutes equals one-tenth the length of the subchord $= \frac{L}{10}$, this multiplied by N² (4, 9, 16, 25, 36, 49, 64, 81, 100, etc.), gives the deflection in the first horizontal line of tables; multiplying these deflections by 2 (see (5)), gives the deflection in the first vertical column of the tables. It will be noticed that the differences of deflections in the diagonal lines following the line of blank spaces are constant differences, and, for the first lines next the blank lines the difference is the deflection for a 1° curve for distance L; differences for the second, third, fourth, fifth, etc., diagonal columns are respectively 2, 3, 4, 5, etc., times this first difference (see 4).

In constructing the second part of the table, Δ = ½ L N × D' (see 2) or can be taken direct from Table of Deflections by multiplying deflections from P. S. by 3. (see 5).

The next thing done by the writer in tables constructed by him was to get the long chord, as is shown in Fig. 3, which gives details of the long chords, co-ordinates, etc., for the table using 75-ft. subchords. As can be readily seen, the long chord for the fourth station equals the [illegible] of the difference between deflection from P. S. for third and fourth points, times long chord of the third station plus cos. of difference of deflection from fourth station [illegible] P. S. and third point, multiplied by length of subchord.

The instructions, Fig. 1, explain how x and y, the [illegible] ordinates, were obtained. This method of getting the [illegible] ordinates may shock the lovers of higher mathematics, but the writer is free to confess that it was the only [illegible] he fully understood, and the results are correct within limits of tables.

Mr. W. H. Sadler (Engineering News, Aug. 15, 1901,) ably shows how spirals can be put in between curves of different radius, that the writer would not bring up the subject were it not for the fact that he believes some [illegible]

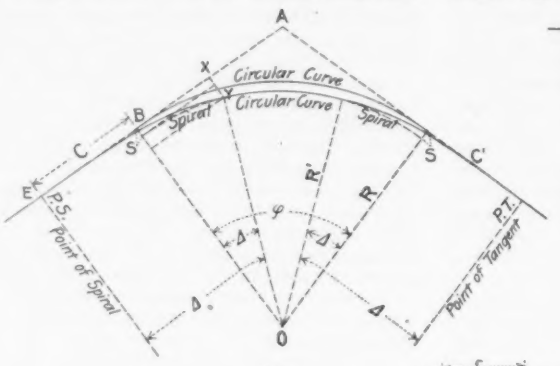


Fig. 1.

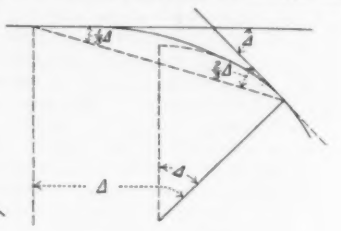


Fig. 2.

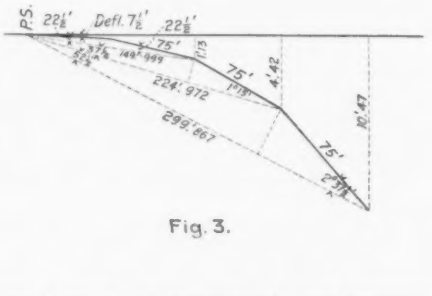


Fig. 3.

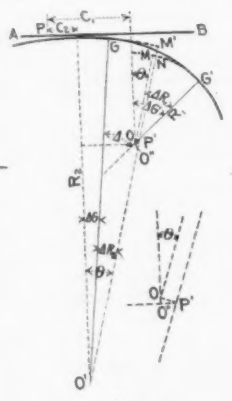


Fig. 4.

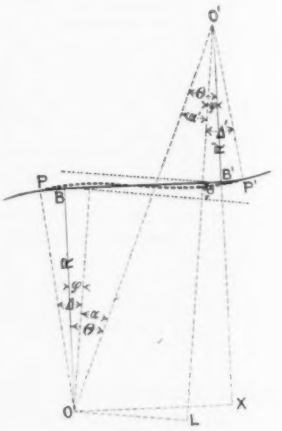


Fig. 5.

FIGS. 1 TO 5. ILLUSTRATING DEFLECTION TABLES FOR LAYING OUT SPIRALS AND METHOD OF USING THEM.

the mathematicians have overlooked a point, namely, that the radii of the two curves do not coincide when a spiral is put in. (See Fig. 4.)

A B = tangent to spiral GG¹ (extended to P where radius = infinity.
Δ G = angle spiral P G.
Δ G¹ = " " P G¹.
Δ, angle of spiral G G¹ = Δ R₁ + Δ R₂ = Δ G¹ − Δ G, as Δ R₁ : Δ R₂ : : D₁ : D₂.
φ = Δ G¹ − Δ R₁ = Δ G + Δ R₂.
C₂ = C for spiral for P G.
C₁ = C for spiral P G¹.
N M¹ = S = S for a D¹ which − D₁ − D₂.
P' O'' = [R₂ − (R₁ + S)] sin φ − (C₁ − C₂.)

Perpendicular distance between

$$M O \text{ and } M^1 O^1 = \frac{P' O''}{\text{Cos } \phi} = P' O. \qquad (10)$$

This is based on the assumption that length of curve equals angle of curve divided by degree of curve, a very common assumption, and, in any case, what is true of the length of curve is true of length of spiral in practical field work. Whatever length of chain the engineer uses on the curve he will be apt to use on the spiral.

Sta.	Point	B.S.	Deflect	L. Angles	R.
+32.5	P.T. ○	3°01.5	6°03'		
1898+17.5			5°45'		
+87.5			5°00'		9°04.5
+57.5			4°03'		
1897+27.5			2°54'		
+97.5			1°33'		
+67.5	P.S. ○	3°42.7	12°35.5		
1896	○	3°22.6	8°52.6		
+50			6°07.6		25°11'
1895	○	0°00'	3°22.6		
+50			0°37.6		
+38.6	P.C. 11°○	2°15'	2°01.5	*Only every other*	
1894+23.6			1°18'	*Point set in this*	
+93.6	○	3°12'	1°36'	*Particular Case.*	
+63.6			0°54'		9°04.5
+33.6			0°24'		
1893+03.6			0°06'		
1892+73.6	P.S. ○	0°00'			

Δ = the Subtended Spiral Angle is = $\frac{N^2 \times L^2}{10}$ Minutes

Sample of Transit Notes.

6.

Table of Deflections 15 ft. SubChord

D	Degree of Curve	0-PS	2	4	5	6	7	8	9	10	11	12	13	14	15	16
0°	0-PS		06'	24'	37½'	54'	1°13½'	1°36'	2°01½'	2°30'	3°01½'	3°36'	4°15½'	5°00'	5°52½'	6°48'
1°	1	12'		24'	43½'	1°00'	1°22½'	1°48'	2°16½'	2°48'	3°22½'	4°00'	4°40½'	5°24'	6°12½'	7°06'
2°	2	24'	30'		17½'	42'	1°01½'	1°24'	2°01½'	2°42'	3°17½'	4°00'	4°48½'	5°30'	6°17½'	7°12'
3°	3	1°15'	56'	21'		24'	51'	1°21'	1°57½'	2°42'	3°31½'	4°24'	5°24'	6°24'	7°31½'	8°39'
4°	4	1°48'	1°48'	48'	25½'		28½'	1°00'	1°36'	2°18'	3°07½'	4°06'	5°18'	6°36'	8°06'	9°00'
5°	5	2°27'	2°00'	1°21'	57'	30'		33'	1°09'	1°48'	2°36'	3°31½'	4°39'	5°54'	7°30'	9°04½'
6°	6	3°18'	2°42'	2°00'	1°36½'	06'	34½'		37½'	1°18'	2°06'	3°07½'	4°18'	5°42'	7°24'	9°22½'
7°	7	4°09'	3°30'	2°45'	2°18'	1°48'	1°16'	39'		42'	1°27'	2°15'	3°15'	4°33'	6°12'	8°07½'
8°	8	5°00'	4°24'	3°36'	3°01½'	2°36'	2°01½'	1°24'	45½'		46½'	1°36'	2°42½'	3°54'	5°42'	7°52½'
9°	9	6°03'	5°24'	4°33'	4°09'	3°30'	2°54'	2°15'	1°33'	48'		51'	1°45'	2°57'	4°51'	6°45'
10°	10	7°12'	6°30'	5°36'	5°18'	4°30'	3°52½'	3°12'	2°30½'	1°42'	54½'		55½'	1°54'	3°55½'	5°57½'
11°	11	8°21'	7°42'	6°45'	6°21'	5°36'	4°57'	4°15'	3°30'	2°42'	1°51'	57'		1°57'	3°03'	5°06'
12°	12	9°39'	9°00'	8°00'	7°33½'	6°48'	6°07½'	5°24'	4°37½'	3°48'	2°55½'	2°00'	1°01½'		1°06½'	2°12'
13°	13	11°15'	10°30'	9°27'	8°46½'	8°06'	7°28'	6°51'	5°57'	5°00'	4°06'	3°04'	2°04'	1°06'		1°09'
14°	14	12°48'	12°06'	10°58'	10°10½'	9°30'	8°46½'	8°00'	7°10½'	6°18'	5°22½'	4°24'	3°22½'	2°18'	1°10½'	

N	Δ	C	Co-ordinates		Long Chord	S	R'	R	D
1	10'	15.00	.05	30.00	30.00	.01	2864.93	2864.94	2°
2	1°12'	30.00	.42	60.00	60.00	.11	1432.69	1432.80	4°
3	1°52½'	37.50	.82	74.99	75.00	.20	1146.28	1146.48	5°
4	2°42'	44.98	1.41	89.98	90.00	.35	955.37	955.72	6°
5	3°40½'	52.46	2.24	104.96	104.99	.56	819.02	819.58	7°
6	4°48'	59.96	3.35	119.92	119.97	.84	716.78	717.62	7°59'
7	6°04½'	67.42	4.77	134.85	134.95	1.19	637.27	638.27	8°59'
8	7°30'	74.87	6.52	149.75	149.93	1.63	573.69	575.32	9°56'
9	9°04½'	82.31	8.70	164.59	164.86	2.17	521.67	523.84	10°57'
10	10°48'	89.73	11.26	179.36	179.77	2.81	478.34	481.15	11°56'
11	12°40½'	97.13	14.33	194.05	194.65	3.56	441.68	445.24	12°54'
12	14°42'	104.52	17.88	208.63	209.30	4.45	410.28	414.73	13°51'
13	16°52½'	111.86	21.95	223.06	224.29	5.46	383.06	388.53	14°47'
16	19°12'	119.18	26.60	237.33	239.01	6.58	359.26	365.85	15°43'

10.

Table of Deflections 25 ft. SubChord

D'	Degree of Curve	0-PS	1	2	3	4	5	6	7	8	9	10	11	12
0	0-PS		02½'	10'	22½'	40'	1°02½'	1°30'	2°02½'	2°40'	3°22½'	4°10'	5°02½'	6°00'
1°	1	05'		10'	25'	45'	1°10'	1°40'	2°15'	2°55'	3°40'	4°30'	5°26'	6°25'
2°	2	20'	12½'		17½'	40'	1°07½'	1°40'	2°17½'	3°00'	3°47½'	4°40'	5°37½'	6°40'
3°	3	45'	35'	20'		25'	55'	1°30'	2°10'	2°55'	3°45'	4°40'	5°40'	6°45'
4°	4	1°20'	1°07½'	50'	27½'		32½'	1°10'	1°52½'	2°40'	3°32½'	4°30'	5°32½'	6°40'
5°	5	2°05'	1°50'	1°30'	1°05'	35'		40'	1°25'	2°15'	3°10'	4°10'	5°15'	6°25'
6°	6	3°00'	2°42½'	2°20'	1°52½'	1°20'	47½'		47½'	1°40'	2°37½'	3°40'	4°47½'	6°00'
7°	7	4°05'	3°45'	3°20'	2°50'	2°15'	1°35'	50'		55'	1°55'	3°00'	4°10'	5°25'
8°	8	5°20'	4°57½'	4°30'	3°57½'	3°20'	2°37½'	1°50'	57½'		1°02½'	2°10'	3°22½'	4°40'
9°	9	6°45'	6°20'	5°50'	5°16'	4°35'	3°50'	3°00'	2°05'	1°05'		1°10'	2°26'	3°45'
10°	10	8°20'	7°52½'	7°20'	6°42½'	6°00'	5°12½'	4°20'	3°22½'	2°20'	1°12½'		1°17½'	2°40'
11°	11	10°05'	9°55'	9°00'	8°20'	7°35'	6°45'	5°50'	4°50'	3°45'	2°35'	1°20'		1°26'
12°	12	12°00'	11°27'	10°50'	10°00'	9°20'	8°27½'	7°30'	6°27½'	5°20'	4°07½'	2°50'	1°27½'	

N	Δ	C	Co-ordinates		Long Chord	S	R'	R	D
1	07½'	12.50	.02	25.00	25.00	.00	5729.65	5729.65	1°
2	30'	25.00	.15	50.00	50.00	.02	2864.93	2864.97	2°
3	1°07½'	37.50	.49	75.00	75.00	.12	1910.08	1910.20	3°
4	2°00'	49.99	1.16	99.99	100.00	.29	1432.69	1432.98	4°
5	3°07½'	62.47	2.27	124.96	124.99	.57	1146.28	1146.85	5°
6	4°30'	74.93	3.93	149.91	149.96	.98	955.37	956.35	6°
7	6°07½'	87.42	6.23	174.81	174.92	1.55	819.02	820.57	6°59'
8	8°00'	99.87	9.30	199.63	199.85	2.32	716.78	719.10	7°58'
9	10°07½'	112.30	13.23	224.33	224.72	3.31	637.27	640.59	8°57'
10	12°30'	124.70	18.13	248.87	249.53	4.63	573.69	578.32	9°55'
11	15°07½'	137.06	24.10	273.18	274.24	6.03	521.67	527.70	10°52'
12	18°00'	149.37	31.23	297.20	298.84	7.82	478.34	486.16	11°49'

DEFLECTION TABLES FOR 15-FT. AND 25-FT. SUB-CHORDS.

Example (11). To put spiral using 25-ft. subchords between a 3° and 8° curve.

Length of spiral = 125 ft.

S = shift for 5° curve using 25-ft. subchords = 0.57 ft. 62½ ft. from P. C. C. will be beginning of spiral. (Neglecting small distance (10)).

△ = 6° 52½'.

Deflections from P. S. to beginning of 8° curve for every 25 ft. are, 25', 55', 1° 30', 2° 10', 2° 55', taken from table for 25-ft. subchords, line 3, in columns 4, 5, 6, 7 and 8 respectively.

Deflections running spiral the other way are 57½', 1° 50', 2° 37½', 3° 20', and 3° 57½', taken from line 8, in columns 7, 6, 5, 4 and 3 respectively.

As to proper length of spirals. Most authors recommend the use of a constant rate proportional to degree of curve; this, the writer considers wrong. Only as the degree of curve affects the elevation of track should it affect the length of spiral. To have good riding track the elevation on the curve should be uniform for its entire length; therefore, the elevation should begin at the P. S. and track should have full elevation at the B. C., or end of spiral. The rate at which this elevation is to be made will determine the length of spiral and not the degree of curve. As examples: Most roads elevate a certain amount per degree plus a constant up to a certain limit, and in the mountains we reach that limit long before we do the maximum degree of curve, besides elevation is governed by other conditions. On our prairie roads a curve at the foot of a sag is put up with more elevation than the same curve would have on a summit. Roads that run trains 60 miles per hour over 2° and 3° curves put in more elevation than our mountain roads where 10° and 14° curves are used, the former also elevate at a slower rate and, therefore, would require a longer spiral on a 3° curve than a mountain road would on a 14° curve. It seems that the authors who advise a constant length per degree have picked out the smallest factor in the problem rather than the result of several.

In putting in spirals on old track, especially in the mountains where curves are very often longer than the tangents, it is much easier to change the tangent than to move the curve. The writer has a solution for this problem which he has never seen in any field book. (See Fig. 5.)

Heavy line indicates original track; heavy dotted line track with spirals; light dotted lines tangents to curves produced.

d = distance between latter = S + S' required.

O L is parallel to the new tangents. As can be readily seen, $\theta' = \theta$ and $\varphi' = \varphi$.

$$O' X = R + R' \text{ and } O X = B B'$$

$$\text{Tan } \theta' = \frac{O X}{O' X};$$

$$O O' = \frac{O' X}{\text{Cos } \theta'} = \frac{O X}{\text{Sin } \theta'} = \sqrt{O' X^2 + O X^2}$$

$$O' L = R + R' + d;$$

$$\text{Cos } \alpha' = \frac{O' L}{O' O}; \quad \varphi' = \theta - \alpha.$$

$\triangle' - \varphi'$ and $\triangle - \varphi$ gives us at once the data from which distances B' P' and B P can be computed.

A knowledge of this problem is also very convenient for the reverse of the above, as in many cases in rough country, owing to poor chainage, it is found when grading is finished and curves carefully chained that the tangents to the two curves are parallel but do not coincide. It will give much less trouble later if a small amount of angle is either added or subtracted from the curves as above instead of changing the degree of the entire curve, or, as is more often done, putting in a piece of compound curve to fit.

John G. Sullivan.

Trail, B. C., Nov. 9, 1901.

(We reproduce below the "Instructions" contained in the blue print book of tables referred to by Mr. Sullivan, together with three of the tables to which reference is made.—Ed.)

R = radius of curve that would join two tangents using same center O as R', radius of curve with spiral.
D = degree of curve, radius R.
D' = degree of curve radius R'.

E x and x y are the co-ordinates of any point, and they are respectively obtained by multiplying the long chord by the cosine and sine of the deflection angle for that point.

S = shift = offset between the tangent and the circular curve, and is obtained as may be readily seen by referring to Fig. 1. It is the difference between x y, the short co-ordinate and $(R' - R' \cos \triangle) - R = R' + S$.

Distance A B = R multiplied by tangent ½ φ, and it could be obtained from semi-tangent tables.

C = distance to be added to semi-tangent in order to get the distance from P. I. to P. S. or P. T. as the case may be., C is obtained by subtracting R' sine △ from E x, the long co-ordinate.

△ is the angle used in the spiral.

φ is the total angle between tangents.

Spiral used shall be a curve whose offsets from circular curve produced and from tangent to spiral vary as the cube of distances. The deflection angles will vary as the square of distances measured on the spiral. The spiral is twice the length of the circle which it replaces, and uses up the same angle (see Fig. 2), one-third being required to set the end of spiral and two-thirds to turn tangent at end of spiral.

The following tables are so constructed that the curvature increases 1° in the distance given as the length of the subchord. Therefore, as can readily be seen, N, the number of subchords in a spiral equals D, the degree of the circular curve. The length of the spiral chosen where possible should be 60 ft. for each inch of elevation to be given the circular curve, so that the beginning of elevation may start at the beginning of the spiral.

The following is the formula for getting the deflections:

$$\text{Deflection in minutes} = \frac{N^2 \times L}{10}.$$

Where L = length of subchord and N = number of subchords up to the point being deflected for.

The explanation is as follows: Since spiral equals twice the length of circle replaced and the length of spiral = N x L; △ in degrees $= \frac{\frac{1}{2} N \times L \times D}{100}$, or to reduce same to minutes, we have $\triangle = \frac{\frac{1}{2} N \times L \times D \times 60}{100}$. Now, since D = N, cancel, and the deflection angle $= \frac{N^2 L}{10}$.

20.

Table of Deflections 75 ft. SubChord

Degree	Transit at	0 - P.S.	1	2	3	4
0°	0 - P.S.		0° 01½'	0° 30'	1° 07½'	2° 00'
1°	1	0° 15'		0° 30'	1° 15'	2° 15'
2°	2	1° 00'	0° 37½'		0° 52½'	2° 00'
3°	3	2° 15'	1° 45'	1° 00'		1° 15'
4°	4	4° 00'	3° 22½'	2° 30'	1° 22½'	

N	Δ	C	Coordinates		Long Chord	S	R'	R	D
1	0°22½'	37.50	.016	75.00	75.00	0.04	5729.65	5729.71	1°
2	1° 30'	74.99	1.31	149.99	150.00	0.39	2865.08	2865.58	2°
3	3°22½'	112.45	4.42	224.93	224.97	1.11	1910.57	1911.66	3°
4	6° 00'	149.81	10.47	299.69	299.87	2.62	1433.85	1436.47	4°

Deflection Table for 75-ft. Sub-Chords.

To run a spiral with transit when set up at P. S. = O, the deflection in minutes for any subchord point is as shown above, $= \frac{N^2 L}{10}$, and the same can be found in the first line in the "Table of Deflections" for length of subchord chosen. To run the same when the transit is set at P. S., the deflection for any subchord point is equal to the deflection for the simple circular curve (D'), to the point being set, less $\frac{N^2 L}{10}$, which may be found in the tables, beginning at the blank space on the line where D' equals degree of curve being used. N in the formula $\frac{N^2 L}{10}$, should always be taken as the number of subchords from the transit point to the point being set.

This formula $\frac{N^2 L}{10}$ can also be used when transit is at any intermediate subchord or spiral point, but the deflection will then be the deflection for the simple curve at the transit point up to the point being set, plus or minus amount given by the above formula.

For all even degrees of curves, the deflection will be found in "Deflection Tables" from any spiral point to any other ditto. If the curve contains a fraction of a degree, the deflection can also be found from the formula as shown in the following example:

To spiral a 6° 15' curve, using 20' subchords, N = 6¼, L = 20, $\frac{(6\frac{1}{4})^2 \times 20}{10} = 78' = 1° 18'$ = the deflection from P. S. to end of spiral. $\triangle = \frac{(6\frac{1}{4})^2 \times 20 \times 3}{10} = 3° - 54'$. To get tangent at end of spiral, say P. C., take backsight on P. S. and deflect 2° − 36' = (3° 54' − 1° 18'), 2° 36' being, as will be noticed, twice the deflection angle from P. S.

Example referring to above form for "transit notes." It is desired to put in an 11° curve with spiral using 15-ft. subchords: Table 6 gives: R = 523.84. Subtangent (which can be obtained from tables using 10° 57' curve) is = 523.84 x tang. 21° 40' = 208.11. (φ = 43° 20'). 208.11 + (C) 82.31 = 290.42. 1895 + 64 − 290.42 = Sta. 1892 + 73.6.

Sta. 1892 + 73.6 = P. S. △ = 9° 04.5'
" 1894 + 38.6 = P. C.
" 1896 + 67.5 = P. S. 11° − 25° 11'
" 1898 + 32.5 = P. T. △ = 9° 04.5'.

The Length of a Vara.

Sir: In your issue of June 12 your correspondent, Mr. W. P. Bullock, graphically describes his experience on being confronted with the unaccustomed Spanish unit of measure, the vara, and the method by which he arrived at an equivalent for it in inches.

Mr. Bullock, finding the (approximate?) value of the foot given as 0.36 vara, deduces therefrom the value of the vara as 33⅓ ins.

Trautwine's "Civil Engineer's Pocket Book" says: "The vara of Castile equals 32.8748 ins., or almost precisely 32¾ ins., or 2 ft. 8⅞ ins. In California the vara by law equals 33.372 U. S. ins."

With
1 vara = 32.8748 ins.; 1 ft. = 0.36502 vara;
1 vara = 33.372 ins.; 1 ft. = 0.35958 vara.

It is true that the vara is not separately indexed; but the index contains the items, "Measures, Spanish," and "Spanish measures." Yours truly,

John C. Trautwine, Jr.

257 S. 4th St., Philadelphia, June 19, 1902.

Sir: If your correspondent from Letot, Texas, will secure any number of the "Consular Reports" issued by the State Dept. he can find a list of 9 "varas" used in Spanish-American states. The vara is commonly used here, although most records require it to be reduced to meters. There is another "vara" attributed to Central America of 28.87 ins., but it does not appear of this length in many cases. Yours very truly, R. W. B.

Matanzas, Cuba, June 20, 1902.

(We quote the table as given in "Consular Reports" as follows.—Ed.)

Vara.....	Argentine Republic	34.1208 ins.
Do.....	Central America	32.87 ins.
Do.....	Chili and Peru	33.367 ins.
Do.....	Cuba	33.384 ins.
Do.....	Curacao	33.375 ins.
Do.....	Mexico	33 ins.
Do.....	Paraguay	34 ins.
Do.....	Spain	0.914117yd.
Do.....	Venezuela	33.384 ins.

Sir: In reading over my Engineering News for June 12 I came across a letter by Mr. W. P. Bullock in which he gives the English equivalents for some Spanish measures.

In view of our recent absorption of several Spanish-speaking islands, many American engineers, in the future, will be called upon to use the data furnished by Mr. Bullock.

However, I would like to caution those not familiar with the Spanish-speaking countries upon the use of these equivalents. While Mr. Bullock's lengths are good in Texas, they may not be applicable in other countries. Spain had a standard of measurement, but I can state positively that her colonies, for some unknown reason, have, in many cases, modified this standard. There are two varas of different lengths in Cuba—the Spanish and the Cuban vara.

I have noticed other differences between the old measures as used in Cuba, and those used in Spain, Mexico and South America. I might cite, as an example, the vara of Castile, as given in Trautwine (32.8748 ins.) as against 33⅓ ins., given by Mr. Bullock for Texas. In California 33.372 ins. is the legal vara.

Since coming to Cuba, I have picked up the equivalents of a few of the old measures used here. These I would like to add to the list already given for Texas.

In all recent work the vara, cordel, etc., have been superseded by the metric system. They hold an analogous position to the old Gunter's chain in our own country. Very respectfully,

H. A. Young.
Assistant Engineer, Department of Cuba.

Tacon 3, Havana, Cuba, June 19, 1902.

OLD MEASURES USED IN CUBA.

Una vara (Cubana)	= 0.848 meter.
Un cordel "	= 20.352 meters.
Un pie (foot) "	= 0.28266 meter.
Una pulgada* "	= 0.02355 meter.
Una linea "	= 0.00196 meter.
Una caballeria"	= 324 (cordeles cuadrados) sq. cordels
Una caballeria"	= 13.4202 hectares.
One acre "	= 40,046.872 sq. meters.

*(Inch.)

Cuban Square Measures.—Caballerias reduced to hectares, square meters, Cuban varas, Havana solares and square cordeles.

Caballerias.	(Hectareas) hectares.	(Metros cuadrados) square meters.	(Varas cuadrados) square varas.	Solares.	(Cordeles planos) square cordeles.
¼	3.3550516	33,550.516224	46,656	43.2	81
½	6.7101032	67,101.032448	93,312	86.4	162
¾	10.0651549	100,651.548672	139,968	129.6	243
1	13.4202065	134,202.064896	186,624	172.8	324
2	26.8404130	268,404.129792	373,248	345.6	648
3	40.2606195	402,606.194688	559,872	518.4	972
4	53.6808260	536,808.259584	746,496	691.2	1,296
5	67.1010325	671,010.324482	933,120	864.0	1,620
6	80.5212389	805,212.389376	1,119,744	1,036.8	1,944
7	93.9414454	939,414.454272	1,306,368	1,209.6	2,268
8	107.3616519	1,073,616.519168	1,492,992	1,382.4	2,592
9	120.7818584	1,207,818.584064	1,679,616	1,555.2	2,916
10	134.2020649	1,342,020.648960	1,866,240	1,728.0	3,240

Notes and Queries.

In the obituary notice of Prof. J. B. Johnson, printed in our last issue, two errors occurred, due to the haste with which the item was put in print from telegraphic dispatches. Prof. Johnson's summer home, where the sad accident occurred that caused his death, was located at Pier Grove, Michigan, and not in Wisconsin, as stated in our item. Near the close of the notice the University of Michigan was referred to as the location to which Prof. Johnson removed on severing his connection with Washington University, at St. Louis; but this should have read the University of Wisconsin, as was, indeed, stated at the beginning of the notice. We hope to present a more adequate biographical notice of Prof. Johnson in our next week's issue.

THE DESIRABILITY OF USING A SINGLE GRADE OF STEEL FOR BRIDGES.

In our issue of June 26, we printed a discussion on the desirability of specifying a single grade of open hearth structural steel for bridges of ordinary span, which took place at the annual convention of the American Society for Testing Materials. Since then we have received the following addition to this discussion from Mr. T. L. Condron, M. Am. Soc. C. E., of Chicago, Ill., which presents some rather important information not brought out by the previous discussion:

At the third annual convention of the American Railway Engineering and Maintenance of Way Association held in Chicago, March 18, 19 and 20 of this year, the subject of specifications for rolled steel was presented in the form of a report of the committee on iron and steel structures. That committee, gathered statistics upon the subject of specifications in use, and sought the opinions of a large number of engineers and manufacturers. The replies received from 40 correspondents, showed the following opinions or preferences: In favor of two grades of steel, "soft and medium": 14 railways, 7 manufacturers of steel, 9 consulting engineers, and 7 scientific schools; in favor of one grade of steel: three railway engineers; one favoring 55,000 to 65,000 lbs., one 57,000 to 66,000 lbs., and one 58,000 to 68,000 lbs.

Notwithstanding the apparent general opinion in favor of two grades of steel, it was known to the committee that a large number of engineers limited themselves to one grade of steel in their bridge specifications. It was therefore proposed to the general committee, by the sub-committee having the matter directly in hand, that a recommendation be made by the entire committee of one grade of steel for bridge building, to be known as "structural steel," having a range of ultimate tensile strength of 55,000 to 65,000 lbs. per sq. in. This proposition was not favorably received by all of the committee, and the objections to such a recommendation were briefly these, as stated in the convention:

The users of medium steel do not see why they should rule out what they believe to be a very excellent grade of steel between 65,000 and 70,000 lbs., if it is to be reamed, and place the upper limit at 65,000 lbs. It has been stated that the same class of service is required of practically all our bridges that are built, which is true; but the structures are built in two radically different ways by different railway companies. A large percentage of the railways entering Chicago, and our western roads, are having their bridge material reamed; the reamed tonnage is constantly increasing and is a considerable proportion of the tonnage for our Western roads. On the other hand, some roads have not come to this reaming so generally. Of the two classes of structures, one is the class where the material is punched and not reamed, and the other the class where the material is punched and reamed, and the advocates of the two classes of steel are those who believe in reaming, and believe they can use a higher unit of strength where the material is reamed. They do not see why they should limit their working stresses to such a low point as is only permissible for work that is simply punched. That is the gist of the whole argument and the reason why some of this committee have declined to agree on a 55,000 to 65,000-lb. steel.

On June 10th this subject was again discussed at a meeting in Chicago by the following bridge engineers: Mr. Parkhurst (Ill. Central), Mr. C. F. Loweth (C., M. & St. P. & O.), Mr. W. H. Finley (C. & N. W.); Mr. W. S. Dawley (C. & E. I.); Mr. Cartlidge (C., B. & Q.), Mr. A. Ziesing (American Bridge Co.); Mr. Allen (Wisconsin Bridge Co.) and Messrs. Ralph Modjeski, J. W. Schaub, C. L. Strobel, and the writer, consulting engineers. The general opinion expressed was that one grade of steel would be more desirable for structural purposes than two, both for the manufacturer and user, but that 55,000 lbs. is unnecessarily low for the lower limit. While all of these engineers are in favor of reaming of main sections, they realize that some roads are not doing so at this time, and will therefore wish to use softer steel than would satisfy those who ream. On the other hand, the steel used for buildings is nearly always the so-called medium steel, 60,000 to 70,000 lbs., which is not reamed. It is, therefore, likely that objection would be raised to reducing the strength of building steel below the present 60,000-lb. minimum. If the engineer could be satisfied that the tests reported to him, fully, as well as fairly represented the physical properties of the steel he is using, he would have no objection to an extreme range of 10,000 lbs. in ultimate tensile strength, but he realizes this is not the case, and with only the few tests (frequently but one for a heat of 30 to 40 tons), he must allow for a variation of 4,000 or 5,000 lbs. below or above the result of the test reported. For this reason he thinks he should restrict the range of tensile strength to 8,000 lbs. instead of 10,000 lbs. Therefore in the Chicago meeting above referred to, the general opinion was that a single grade of steel, having a range of tensile strength as shown by the ordinary tests, from 58,000 to 66,000, or 54,000 to 65,000 lbs. as a second choice would come the nearest to suiting all interests concerned so far as railway work is concerned.

Regarding ranges of physical properties in any one melt of steel and the likelihood that steel varying from 4,000 to 6,000 or even 8,000 lbs. above or below what any one test shows, attention is called to the results shown in the tables appended.*

The first table shows the maximum and minimum results and the differences between these results from tests of plates of the same thickness, and from the same heat. These tests were made on a lot of 200 tons of basic open-hearth plates, rolled from 13 different heats into five different gages. It will be seen from the second table, which is condensed from the first, that in the case of the ultimate strength the variations in one gage and one heat were from 2,500 to 8,800 lbs., including an exceptionally wild heat of 12,300 lbs. per sq. in. Similarly the yield point varied 1,700 to 12,600 lbs. per sq in., and the elongation varied from 3 to 12%. In the third the results of tests from another lot of plates are shown. In this lot the variations of ultimate strength in the same gage and heat were from 1,300 lbs. to 8,500 lbs., and in yield point from 1,500 lbs. to 12,200 lbs., and in elongation from 1 to 7. These are not exceptional results, but are what are constantly observed, and if variations of 6,000 and 8,000 lbs. in ultimate strength are found in the same gage and heat it must be conceded that as great or greater variations are to be found in differing gages of the same heat. Therefore, if only one test, or even two tests per heat are required, it is important that such tests fall within narrow limits. If more tests are to be made, then it would be rational to expand the limits allowable for such tests.

In conclusion, the writer believes that the time has come for recommending a single uniform specification for structural steel for ordinary uses (not including rivets and pins), and since American manufacturers have demonstrated that they can make a steel of an average tensile strength of about 62,000 lbs. he would favor 62,000 lbs. as a basis, making the range 4,000 lbs. above or below 62,000 lbs. The recommendation of the committee of the Maintenance of Way Association has been for a range of 8,000 lbs., in which tests would be accepted, allowing the making of retests where the first tests are not more than 1,000 lbs. outside of the 8,000-lb. range. In the writer's opinion, this 1,000 lbs. should be made 2,000 lbs. The writer desires to suggest for your consideration, the following range:

56,000 to 58,000 lbs., tensile strength, two retests required; 58,000 to 66,000 lbs., tests accepted; 66,000 to 68,000 lbs., two retests required; below 56,000 lbs. or above 68,000 lbs., rejected.

Of course the other properties would have to be fixed upon in harmony with this range, and rivet and pin steel are not included. The former should be peculiarly soft and ductile, ranging between 50,000 and 58,000 lbs. tensile strength, and the latter quite hard like axle steel, ranging between 75,000 and 85,000 lbs. tensile strength.

*These tables are not reprinted.—Ed.

THE EVIL OF EXCESSIVE DIFFERENTIATION IN ENGINEERING COURSES.*

By Edgar Marburg.†

The subject of specialization in engineering courses may be presented in numerous phases calculated to give rise to prolonged and inconclusive discussion. If attention be confined, however, to its salient features a substantial unanimity of opinion will be found to prevail among engineering teachers. This is manifest from a comparison of the engineering curricula at different institutions. There are, it is true, occasional tendencies towards specialization to an extent which most of us, perhaps, would deprecate. Such instances are, however, exceptional; the curricula, on the whole, exhibit a remarkable degree of accordance.

It should be stated at the outset that the present discussion will be limited to a consideration of the question in its bearing on courses in civil engineering in the commonly understood scope of that division. The aim will be to keep in view average, present-day conditions, rather than conditions more or less ideal which may or may not be realized at an uncertain period in the future. It will accordingly be assumed that the prescribed requirements for admission to the engineering course are such as can be fairly met by the average high school in our larger cities, and that the length of the course is four years. These conditions, fairly characteristic of our better engineering schools, will tend to restrict debate to definite and somewhat narrow limits.

It will doubtless be conceded that the first two years should be devoted mainly to language and science studies, with especial emphasis on mathematics, as the indispensable ground-work for the later technical subjects. The program may also advantageously include various courses in drawing, descriptive geometry, surveying and elementary mechanics. It is believed that this represents fairly the usual curriculum for the first two years. Nor is it easily conceivable how, under present conditions, this program is susceptible of improvement in any essential particular.

I shall not assume to designate more definitely the particular subjects to be included in this first half of a four-year course in civil engineering; still less to specify the relative time to be devoted to each subject. Within reasonable limits these matters must be governed by attendant circumstances and individual judgment. There are, for example, some who hold that all students in civil engineering should receive practice in shop work, and make provision accordingly during the first or second year. Others claim that such work, to the extent to which it can be introduced, is of little or no permanent value. There are again those who, conceding the desirability of such instruction, consider the time element prohibitive. And, finally, there are some who, endowed perhaps with a keener insight or a larger vision, avow their own uncer-

*A paper presented at the annual meeting of the Society for the Promotion of Engineering Education.

†Professor of Civil Engineering, University of Pennsylvania.

tainty. What man, or tribunal of men, can assume to settle such questions with confidence and precision? And who, indeed, will insist that they should be settled to a nicety?

In a general way it is true, however, that the subjects primarily prescribed for the first two years, are of such fundamental and far-reaching importance, that there can be little thought of specialization. While it is conceivable that certain minor options may be safely offered, the curriculum in all essential features must be a rigid one, or the students' interests will inevitably suffer.

In the upper years the course naturally grows more uncompromisingly technical. The cultural subjects are sacrificed to the relief, usually, of the student, though possibly to his ultimate disadvantage. However that may be, the more immediate technical needs are so numerous and apparently so pressing that it seems hazardous to pursue a different course. Moreover, it is necessary to make provision during this period for a group of collateral subjects, which in the aggregate make no inconsiderable inroads on the limited time available. It is believed that no plea for differentiation can avail to justify the excision of such subjects as astronomy, metallurgy, mineralogy, advanced physics, and the law of contracts, however much opinion may differ as to the time that may properly be assigned to these topics. The recognition of geology and assaying, however desirable, appears less essential. Again, any projected scheme of specialization in civil engineering, aiming to exclude instruction—elementary though it be—in steam engines, boilers and pumps, and in industrial electricity, seems fairly open to serious criticism.

Coming now to what for present purposes may be termed the purely civil engineering subjects, and leaving from account those covered during the first two years, it may be reasonably maintained that every course should include the theory of mechanics of materials, framed structures, railway and highway construction, hydraulic works, masonry and foundations, and a study of the physical properties of the materials of construction. But instruction in theory is largely misdirected unless it be duly supplemented by design and laboratory work. Experience has shown that it is possible in no other way to invest theoretical study with definite meaning to the student; to transform seemingly abstract and abstruse principles into glowing realities calculated—under competent and inspiring leadership— to arouse the student's interest to the point of unfeigned enthusiasm. By a judicious apportionment of time the principal technical branches may each receive this vitalizing touch to the great profit of the student. But the program thus supplemented leaves obviously scant room for specialization. Under favorable conditions it may be rounded out by a limited number of free electives among subjects of less general importance to the average practitioner, such as geodesy and cartography, railroad economics, river and harbor works, stereotomy, the bacteriology of water, special lines of municipal engineering, etc. It is believed that in such limited measure, and in such measure only, may undergraduate specialization be permitted without detriment, and possibly with some advantage to the average student. On the other hand, specialization in which the elaboration of one or two branches entails the suppression or mutilation of other important subjects, not absolutely indispensable to the narrow end in view, is looked upon as a grievous wrong to the student, and one of which he will soon be made aware in after life. It is sometimes said that there is a popular demand for such courses, with which the schools must reckon. The writer has seen little or no evidence of such demand. But, after all, a scheme that has intrinsic merit need not be bolstered up by such an argument; and in the absence of such merit the plea itself falls to the ground. It is believed that no apparent popular demand will serve to justify the establishment of highly specialized undergraduate courses; and it is gratifying, therefore, to observe that the schools themselves have not yielded to this temptation in any marked degree.

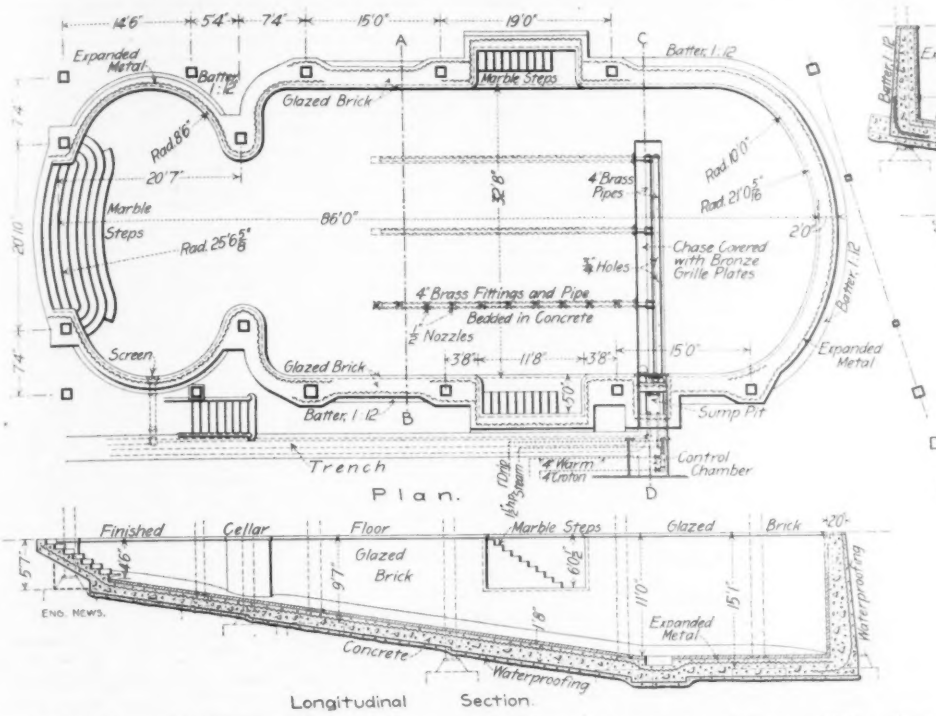
The fact that most engineers find it expedient ultimately to confine themselves to the practice of some single specialty may be adduced as an argument not for, but against, similar differentiation in the preparatory courses. Every specialist should possess a fair knowledge of kindred branches. Without some breadth of view, he can not hope to rise to eminence. The greater the difficulty of acquiring such collateral knowledge in practice, the greater the need of its presentation in the schools.

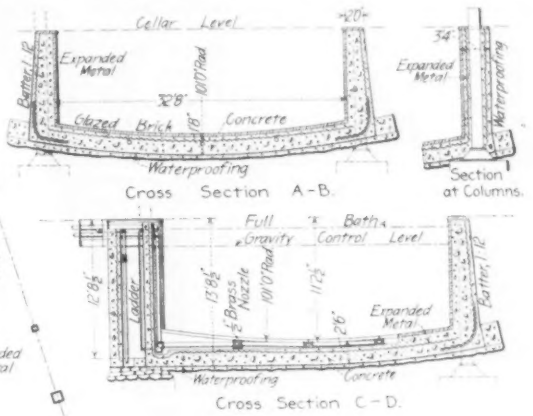
Again it may be asked, how many engineering students have their immediate professional future safely predetermined even three months before graduation? That the proportion is exceedingly small there can be no doubt. It may be safely affirmed, further, that the average undergraduate is incapable, by any rational process, of arriving at his choice of a specialty. Hence, the more varied the course, the better the opportunity of determining his preference. Otherwise he is like one obliged to make a choice between untasted dishes, guided by instinct alone. And he who hazards the choice of a highly specialized course is surely less fitted for employment in other lines should he discover upon graduation that he had erred in his fancied preference, or should he fail to find a ready opening in his chosen field. And lastly, it is held that no wiser provision can be made against the vicissitudes to which an engineering career is peculiarly liable than may be found in the broadest possible course of preliminary study.

That specialization in engineering education is becoming increasingly important is by no means denied. But in the writer's view its place is not in undergraduate courses. Its legitimate province is to be found in graduate instruction, and there no limits need be set to its intensity. But schools not thoroughly equipped for this responsible work had better not attempt it. Graduate courses, if offered, should be truly worthy of the name. They should appeal to men in practice as something worth striving for. Their value should be absolutely beyond question. This means they must be conducted by an adequate corps of able and experienced specialists, as, for example, in our best schools of medicine. In the writer's judgment the fewest number of engineering schools professing to give graduate courses are really fitted for such work. The result is seen in somewhat nondescript fifth-year appendages of doubtful value attached to four-year courses of unquestioned excellence.

A CONCRETE-EXPANDED METAL SWIMMING TANK FOR A NEW YORK APARTMENT HOUSE.

In the construction and equipment of the large 16-story apartment house situated at 74th St. and Broadway, in New York city, there was built in the basement the swimming tank, of concrete-steel construction, details of which are shown in the accompanying illustrations. The drawings show the construction so clearly that but very little description is required. As will be seen, the metal element of the tank is expanded metal; all other portions of the structure are of concrete, except, of course, the glazed brick lining, marble steps, iron railing, etc. In plan the tank is unusual, owing to the necessity of getting it between the building columns. Otherwise its design is of ordinary character. The architects of the building are W. E. D. Stokes and Paul E. Du Boy, of New York city. We are indebted to Mr. Merrill Watson, of the New York Expanded Metal Co., New York city, for the drawings from which our illustrations have been prepared.





DETAILS OF CONCRETE AND EXPANDED METAL SWIMMING TANK FOR APARTMENT HOUSE AT 74TH ST. AND BROADWAY, NEW YORK CITY.

THE EFFICIENCY FACTOR IN ENGINEERING EDUCATION.*

By Robert Fletcher, Ph.D.†

The title of our society expresses the object of this convention. We come from widely separated localities, from different environments and from institutions variously organized and conducted, to take counsel together. Our high ideals may need readjustment. Our work and duty as teachers must not fail to conform to the rapidly changing conditions and demands of the active interests which we strive to serve.

In presenting a few thoughts on "The Efficiency Factor in Engineering Education," we face at once the ancient question of *education* versus *training*. Although technical education has been under lively discussion among American engineers and educators for nearly 30 years, it is only yesterday, as it were, that the president of a leading institute of technology thought it necessary to utter an emphatic warning against the danger of putting too much stress upon mere *training*, to the neglect of the broader education. As far back as the Philadelphia discussion of 1876, methods in England were criticised because the results came so far short of the American ideal of engineering education, being too much limited to training of artisans—yet only within five years the leading engineering journal of Great Britain has poured contempt upon the inadequate and misdirected systems still in vogue there—showing the vast difference between educating well-fitted men to become directors of works and masters of professions and the endeavor to teach workmen and laborers much that they cannot properly utilize.

If we are to bring any large extent of industrial education within our purview, it is a fair suggestion whether our title might not better be: "Society for the Promotion of Technical Education." But let us rather consider that our past history and present aims are better expressed by the term engineering education. In that case we understand that "Engineering" includes "technical" so far as that designates what makes for the professional endowment of the man; and that *education* includes *training*, as the whole includes a part, only without neglect of the broader culture, and without too much emphasis upon mere drill and manual dexterity.

A factor of efficiency, whether in mechanics or education, is a product of other factors, usually of many. The effectiveness of engineering education is greatly influenced and determined by the *purpose* in view, the *personnel*, both of teachers and taught, the *substance* *methods*, the *machinery* and the *cost*.

*Condensed from the Presidential address before the Society for Promotion of Engineering Education, Pittsburg, Pa., Annual Meeting, Jan. 27.

†Director of Thayer School of Civil Engineering, Hanover, N. H.

First, as to the *purpose*: Much waste of educational effort results from indefinite aim. In the public schools, while studies are in some degree adapted to an end, that end is often very general rather than specific. There are too many educational fads and experiments. Results are good—better than we might expect—but it is a familiar remark that one, two or more years were spent in school to little purpose, and that misplaced studies were pursued with small profit.

The best examples we have of a definite purpose realized with a high factor of efficiency are the military and naval academies of the United States. These give the extreme type of *training*—drill and rigid discipline. During the last years of the life of the late Gen. Sylvanus Thayer, the "Father of the Military Academy," the writer had the privilege of hearing from the lips of that great organizer and model superintendent, statements of his policy and methods. Efficiency has been attained and maintained by strict discipline, involving close supervision of the life of the cadet, and the impartial infliction of sure penalty for every transgression; the assignment of the maximum of time to studies, drills and manly exercise; the cultivation of the spirit of obedience, truthfulness and devotion to duty; and the rating of men strictly according to merits. Here we have the perfection of training—the broader education lacking except in those who had previous opportunities before entrance.

But our engineering institutions generally do not have an aim so single and cannot so well control all of the conditions necessary to realize it. Yet if *requirements* for *graduation* were in all cases clearly defined and specified, and adequate tests impartially applied, a more distinct goal would invite all alike, and this factor of specific *purpose* would have its highest value. How well this goal is now defined may appear by looking over half a hundred catalogues and prospectuses of engineering colleges, and then considering the different careers of young men within 10 years after graduation. We find some difficulties and inconsistencies in the various differentiations between civil, mechanical, mining, municipal, sanitary, etc., engineering. Electrical engineering is distinct enough. We cannot avoid the question whether there is not a little too much straining for divergence; whether we cannot better prepare for the inevitable divergence outside the college precincts, by promoting more unity within; whether two or three inclusive degrees, well earned, have not more weight and value than the various and separating degrees now proposed in some quarters.

The right pursuit of a given end is largely determined by the element of time. Many are unwilling, or think they are unable to take time enough. The complaint is made that the raising of requirements of admission defers too long the entrance into practice; but Dean Wright, of Yale University, has shown in his last report that the average age of Yale graduates has increased during the past 40 years only about four months. And this in spite of the fact that Yale maintains the traditional four years' course, that the college courses have been much strengthened, and that, by the Dean's estimate, the time needed for college preparation has increased from one and a half to two years during the 12 years just past. The editor of a leading New York paper, in commenting upon this yesterday, remarked that it is wrong to blame the college for a late start in life, because the professional schools are the real exactors. That brings fairly to an issue the question whether college—that is, general culture—is worth while.

Any discussion of this question, however, must recognize the fact that college courses are not made effective enough even for culture. We know that hundreds, if not thousands, of students in college have very indefinite aims, or none at all. We know that too many distractions are allowed. Athletics—not the reasonable and necessary, but the peripatetic athletics, "Society" claims, glee clubs, dramatic clubs, and a dozen wholly irrelevant activities, disorganize the legitimate work of the student.

As a step toward promoting greater efficiency of the entire scheme we have seen the gradual acceptance, where the old-time college is concerned, of distinct professional courses made as nearly post-graduate as possible. By proper selection of college courses the earnest student can gain in three years practically as much for general culture as the ordinary man usually secured in four, by the old procedure. Two years of professional study—provided so-called "vacations" are also utilized—will then usually suffice.

The writer may be pardoned for alluding to the fact of his experience with this arrangement for more than 25 years. During the period when men took four years in college and two in the post-graduate course, the average age of graduates was quite a little beyond 24 years. During the last ten years, under the better system, the average age of graduates has decreased considerably more than a year. There is a feeling that we do not get men of so good all-around ability as formerly, but just comparisons are hardly possible.

Second, *personnel*: A former president of our society has reminded us that the members should esteem themselves primarily as teachers. Admitting the desirability, or, if you please, the necessity, that a teacher of engineering should be or should have been also a practitioner, yet there must be above all a well-marked ability to teach. Let us remember, however, that we are not pedagogues simply, but teachers of *engineering*. We should be more identified with engineers than with teachers, and our society affiliations should not be with education associations but with societies of engineers. The benefits derivable from the former are less serviceable to us than the opportunities and inspirations afforded by the latter.

The personnel of the student body is one of the largest factors of our large problem. We would determine the qualities of our student material by our requirements for admission. But this is only an academic or—if you please—a mechanical test. We recognize the quality of character and inherited traits, as of greater importance. "Blood tells." If unsullied honor and unquestioned integrity are expected in the cadet or officer, much more should these virtues characterize the engineer. Hence, with all our requirements we must require the highest character. All our constructions must conform strictly to the principles and conditions which nature imposes; he who violates her laws whether through ignorance or carelessness or guilty intent, cannot escape her penalties. A deceitful, dishonest or unreliable engineer is a traitor to a profession whose ideal of truth is exactness, whose standard of performance is uprightness and wholeness—whose symbols are the plumb, compass and level. Our engineering colleges must not fail to nurture the heartiest esprit du corps, or to exclude any who are not entirely trustworthy.

Third, efficiency as determined by the *substance* and *methods* of instruction. How much and how?

Fifty years ago the legacy from the past to the few engineering students was small; the printed body of recorded practice was meager. The instructors of that day could be deliberate; they revelled in mathematical theory; they incurred the odium of being impractical. At the beginning of the 20th century the multitude of students look to the engineering schools and colleges to put them in possession of an inheritance almost too large to grasp, and ever increasing. Nevertheless, the school or college of to-day is still in the same relative place at the bottom of the professional structure.

Let not the aspect of magnitude tempt us to get too far above the foundations. In almost every line of modern engineering practice the graduate must serve as an apprentice before he is competent to take much responsibility. The exceptions to this are rare. Let the subjects taught be so primary and fundamental, and so thoroughly mastered, that nothing will have to be unlearned, and that the period of apprenticeship will be short.

The range of primary and essential topics is now so much greater than formerly that we have no room for non-essentials. Some present tendencies do not conform to this principle. For example, many books intended for instruction are too bulky and too diffuse; they are treatises rather than effective text-books. We have not simply an embarrassment but a flood of riches, in a vast accumulation of data and newly-developed theory, from which it is difficult to make a wise selection; definitions and primary concepts need more emphasis and iteration than statistics and details.

The efficiency of instruction at our national academies has been attributed to the blackboard system. This includes—daily recitation from a text-book, with a blackboard demonstration; sections limited to 10 or 12, and each recitation a possible cross-examination; lectures are rarely given; eight or ten advance lessons are followed by four or five in review, and a general review precedes the subject examination, thus giving the proper repetition which is an element of good teaching.

When pushed to extreme this method leads to too much effort in preparing the lession for *recitation* only; there may be more anxiety as to class standing than concern to gain the right mastery of the subject. But it holds the men to their work, and the shirk cannot escape detection. It is so easy and often so pleasant to talk to a class that the teacher may forget that his primary duty is to learn what each man knows of the subject, and explain only what the student cannot himself ascertain. Disappointment and chagrin at the small results from well-prepared class-room talks and lectures is a too common experience of all who try to instruct.

Fourth, *machinery* as related to efficiency in engineering education includes all instruments, apparatus, machines, engines, models, etc. In looking at the now abundant equipment of our colleges we make at once a natural division into: those without which effective instruction cannot be given, those which are desirable but not necessary, and those which are superfluous, if not indeed burdensome. If we should attempt to get an agreement right here as to what these several divisions should include, we should probably fail. It is said that a good workman is one who can do good work with poor tools. The history of engineering education gives conspicuous proof of this in the days of small things. But *efficiency* of operation is possible only with the best tools that can be had. If an institution proposes to maintain a complete testing laboratory for mechanical or other tests of materials, an equipment of large and expensive machines may be justified. But for the *legitimate purpose of instruction* a few machines of moderate size, which the students can operate for themselves, is the most useful and effective plant.

Little need be said about apparatus simply desirable but not necessary. At best it serves for purposes of illustration. In this category may be included nearly all models which make the stock in trade of dealers, and many that are made by students. Their value is temporary; they accumulate; they are put aside into a store-room or museum. Lessons may be found, it is true, in museums and scrap-heaps; but interest in such collections soon wanes, and, after a while, they serve chiefly as vouchers for ineffective expenditure.

As to what machinery and engines would be considered superfluous in the colleges is a question provocative of lively discussion. If research, more or less extensive, is to be generally recognized as a function of the engineering college or university, then a plant of almost any magnitude or cost may be justified. But, whatever advantages accrue to the profession from such establishments, they must be considered to be exceptional institutions. The use for *instruction* to the body of students is and must ever be quite limited. Their efficiency in the general scheme is small in proportion to magnitude, initial cost and cost of operation.

Fifth. In all modern engineering operations, especially in the United States, the principal criterion of efficiency is cost. It is certain that the highest efficiency is not determined by the largest endowments or the most extensive equipments. If we could have ideal students working with ideal instructors, both would use a minimum equipment to the best advantage. Again, the final estimate of the cost goes beyond the money outlay, and cannot be made until the professional development of the man is in evidence. There is an obvious tendency towards some extravagance in buildings and equipment. The ideas of an expensive architect are sometimes allowed to govern, when an engineer would secure the maximum of utility at far less cost. The disposition in some quarters to put too much of large endowments into buildings, lessens the funds for providing the maximum man-power, without which a grand structural plant is of small account. Hesitation to pay the full price for the best instruction is fatal and mistaken economy. The principle here is: good men at any price; a good plant at the least cost consistent with utility.

Finally, we would be governed by the prime principle of the engineering profession, which is to derive the largest and best output possible from the judicious expenditure of money and labor.

THE BRITISH HOUSE OF COMMONS is in a bad way, from a sanitary point of view, says a London exchange. The recent indisposition of some of the members is explained by the statement that there is an unventilated main sewer under Palace-yard, and a network of bad drains in the vicinity. With the rise and fall of the tide the sewer gas is forced into and about the building.

NOTES FROM THE ENGINEERING SCHOOLS.

HARVARD UNIVERSITY.—The "Harvard Engineering Journal," for April, 1902, contains a detailed history of engineering instruction at Harvard, contributed by James Lee Love, Asst. Prof. of Mathematics, and Secretary of the Lawrence Scientific School. The sketch commences in February, 1847, with the approval of a plan for establishing the Scientific School of the University at Cambridge. It was apparently the first graduate school established by any college in this country, as "all graduates of the University, or of any other collegiate institution" were admitted, along with others of suitable age and qualifications. Abbott Lawrence, in June, 1847, gave $50,000 for this purpose, and the name of the new school was changed to the Lawrence Scientific School in the University at Cambridge. Mr. Lawrence assisted this school financially during his life, and left it a second $50,000 at his death in 1855. Lawrence Hall was built in 1848; and among the first instructors were Louis Agassiz, professor of zoology and geology; and Henry Lawrence Eustis, who was made professor of engineering in 1849, and retained that position until his death in 1885. The sketch gives the succession of the faculty, courses adopted, growth of the school, etc.

IOWA STATE COLLEGE.—Mr. M. J. Riggs, Manager of the Toledo Branch of the American Bridge Co., recently described to the engineering students the construction and operation of the bridge plant in his charge, including the use of electric power with separate motors for machines, and crude petroleum used as fuel in the furnaces.

The new Engineering Hall of this college is nearing completion. It is a four-story building, 208 × 100 ft., fireproof throughout, and cost $175,000.

The Department of Mining Engineering is conducting a summer school in Colorado, under Prof.

S. W. Beyer; and the Civil Engineering School has just concluded some field work near Boone, on the Des Moines River. This work included a triangulation system, the accurate contouring of about 10 sq. miles of territory, the sounding and mapping of the river, and the gaging of its flow. About 50 students were in this camp.

AN ELECTRO-PNEUMATIC TRACTION SYSTEM.*

By Bion J. Arnold.†

During the past three years, as many of the members of the Institute know, I have advocated the use of the alternating current motor for certain classes of railway work somewhat earnestly, and have often been asked by my friends why I believed so thoroughly in the alternating current motor, and have been questioned rather closely at times for particulars regarding a certain system which I have been working upon.

I wish to state that long before I had any fixed ideas as to a system of my own, a study of the railway question from an engineering standpoint partially convinced me of the necessity of the ultimate abandonment of the direct-current motor for heavy and long-distance service, due to the low working voltage that it was necessarily limited to, the resulting heavy investment in transmission lines thereby required, and the many translations between the power station and the car when any great distance was taken into account.

An active connection with the development and construction of electric railways in this country impressed me with the correctness of my preconceived ideas to such an extent that they finally crystallized into a system of electric railway construction upon which I have been working for several years, and to which I have alluded from time to time without giving, to those not interested with me, any definite information regarding it, for reasons well known to those working upon new devices.

I have constructed 20 miles of road for this system, together with the necessary trucks and motor equipments, and as I feel reasonably sure of the interest you will take in this system, I feel warranted in presenting it at this time.

The recent discussions of this question that have been going on between engineers of Europe and of the United States have made the subject a live one at present, and this is my reason for presenting a brief description of my system at this meeting.

The principles underlying the system I advocate and which I call an electro-pneumatic system are as follows:

A. A single-phase or multiphase motor, mounted directly upon the car, designed for the average power required by the car, and running continuously at a constant speed and a constant load, and, therefore, at maximum efficiency.

B. Instead of stopping and starting this motor and dissipating the energy through resistances, as is customary with all other systems known to me, I control the speed of the car, by retarding or accelerating the rotor or the stator of the motor, by means of compressed air, in such a manner that I save a portion of the energy which is ordinarily dissipated through resistances, and store it to assist in starting the car, helping over grades, for use in switching purposes, and for the operation of the brakes.

C. By this method of control I secure an infinite number of speeds from zero to the maximum speed of the car, which may or may not be at the synchronous speed of the motor, for with the air-controlling mechanism working compressing, the speeds below synchronism are maintained, and by reversing the direction of the air through the controller speeds above synchronism may be attained for reasonable distances. This feature gives to the alternating-current motor the element absolutely essential for practical railway work, for it permits a car or train to ascend a grade at any speed with the motor working at its maximum efficiency, and imparting its full power to the car. When descending the grade the motor may utilize its full power drawn from the line in compressing air, or it may be used to compress air with the stored energy of the train, thereby acting as a brake.

D. By virtue of the air storage feature each car becomes an independent unit and capable, in case of loss of current from the line, of running a reasonable distance without contact with the working conductor, and this without the aid of storage batteries. This feature will enable a car to work on a high-tension trolley wire or active conductor over private right of way, and allow the active conductor to be stopped where the private right of way ceases, and the car to proceed through a city or town on any tracks, whether electrically equipped or not, until it reaches the outskirts of the city or town where it can take up the working conductor again on private right of way. This feature is also valuable in switching work, for each car being independent it can leave the main-line track and operate over switches or sidings without complicating the yards with additional overhead or third-rail conductors, thus necessitating through line conductors over main-line track or tracks only.

E. Since a single-phase motor can be used the motors can be supplied with current from a single overhead wire or third rail, and with a single-rail return circuit, thus permitting the overhead construction (or the third-rail construction) to conform to the standard of to-day, except that a much higher working voltage can be used, provided the insulation is taken care of. Furthermore, in steam railway work this system, by virtue of its single-phase feature, will only require the use of one of the track rails for the return circuit, thus leaving the other rail for the use of the signal system, which, up to the present time, does not seem to have been satisfactorily solved without the use of one of the track rails.

F. The current will be taken from the working conductor at any voltage up to the limit of the insulation, and in case this voltage is high (I am building my line for 15,000 volts), a static transformer will be carried upon each car and the pressure reduced from the line voltage to the voltage of the motor, which in the case under construction is designed for 200 volts. Where it is unnecessary to utilize so high a line pressure the motor may be designed for the working voltage and the current fed directly from the working conductor into the motor, thus eliminating the static transformer. When a high-voltage working conductor and static transformer is used, and it is thought advisable to use a working conductor through cities or towns this working conductor will be supplied with energy through a stationary transformer at each city limit, thus making the working conductor through the cities or towns safe.

G. By virtue of the speed of the motor and its constant load, either when the car is in motion or when it is standing still, and the motor is compressing air, the variable load now customary in electric railway power plants is eliminated, and the power station works at practically a constant load, thereby eliminating a large part of the investment at present requisite in power station and line construction. Furthermore, by virtue of the air-storage feature, each car, in the particular apparatus I have designed, is capable at any time when current is on the working conductor of delivering to the car wheels a much greater torque in proportion to the capacity of the motor than is possible with any electrical system known to-day.

I believe that by the adoption of this system the following results will be accomplished:

1. The entire elimination of the present standard system of rotary converter substation plant, together with the maintenance thereon and the cost of the necessary attendance.

2. It would absorb and render available for useful work in starting, or otherwise, a large percentage of the energy stored in the moving mass which under the present methods of operation is dissipated at the brake shoes.

3. A large reduction in the first cost of electrically equipping long-distance railroads, thereby making it feasible, from an engineering and business standpoint, to equip many roads which cannot now be shown to be advisable, thus opening up the steam-railway field to the industry in which we are now engaged.

(As intimated in the preceding, Mr. Arnold has at present under construction a 20-mile line on this system. This line will soon be ready for operation, and at that time complete technical details regarding it will be made public.—Ed.)

*A paper presented before the annual convention of the American Institute of Electrical Engineers, held at Great Barrington, Mass., June 17 to 21, 1902.

†Consulting Electrical Engineer, Marquette Bldg., Chicago.

BASCULE BRIDGE AT GRAND AVE., MILWAUKEE, WIS.

(With two-page plate.)

An interesting example of the fixed-trunnion type of bascule bridge has recently been completed across the Milwaukee River, at Milwaukee, Wis. This is probably the first bridge of this type to be completed in this country, although some bridges of a similar type are now being built across the Chicago River (Eng. News, Jan. 31, 1901). The location is somewhat peculiar. There were originally two villages on the opposite sides of the river, and the antagonism between them reached such a point that the main streets leading to the river on either side were purposely laid out so as not to coincide. The city, therefore, has an awkward bend or kink in this main thoroughfare at the river crossing, the south line of Wisconsin St. (on the east side) almost striking the north line of Grand Ave. (on the west side), while the streets are not in line with one another, and are not of the same width. The river also makes a decided turn at this point, which adds to the awkwardness of the situation. The old bridge was a center-pier swing bridge of 180 ft. span, with two through trusses, an 18-ft. roadway and two 6-ft. sidewalks. This was built by the Wisconsin Bridge & Iron Co. in 1881, and has now been removed to Chestnut St., replacing an old structure which has been demolished.

When a new bridge at Grand Ave. was decided upon, owing to the serious congestion of traffic caused by the narrowness of the old bridge, several propositions were made for straightening out the kink in the streets to some extent. The streets on each side were entirely built up, and could not be changed in any way, but one proposal was to put in a bridge about 100 ft. wide, so as to give almost the full width of the roadway at the east end (Wisconsin St.). The bridge roadway would then cover the entire width of the roadway and south sidewalk at the west end (Grand Ave.), and it was therefore proposed to cut an arcade through the corner of the Gimbel Building (at the southwest corner of the bridge) so as to carry the south sidewalk of the street to connect with that of the bridge. This plan, however, would have involved considerable expense for damages to property, and the City Engineer, Mr. Charles J. Poetsch, M. Am. Soc. C. E., considered that a bridge 64 ft. wide would be ample for traffic requirements, and would avoid all property interference, while at the same time its width would allow of an easier crossing than the old bridge. This recommendation was adopted, and the situation is shown by the general plan, Fig. 1. The War Department required a clear channel width of 70 ft., which is the width given by the new bridge, measured at right angles to the general direction of the channel, although the width between the pile protection or fenders is 95 ft. measured on the center line of the bridge.

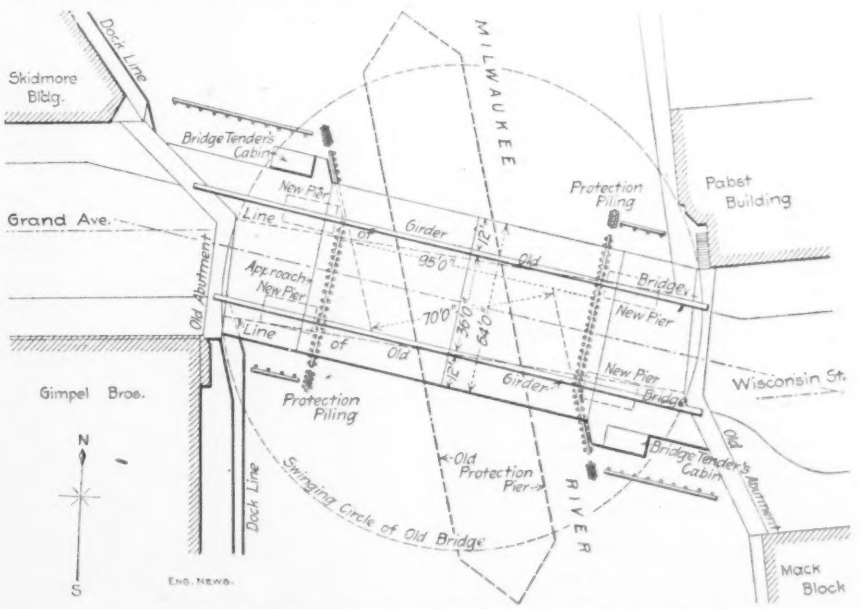


FIG. 1. MAP OF SITE OF GRAND AVE. BRIDGE; MILWAUKEE, WIS.

FIG. 3. VIEW OF BASCULE BRIDGE, CLOSED.

After the general scheme had been adopted, and the width of bridge and other governing features had been decided upon by the City Engineer, bids for competitive plans were invited, and numerous designs were submitted. The plan selected was that submitted by the Wisconsin Bridge & Iron Co., of Milwaukee, and provided for a double-leaf bascule bridge, with fixed trunnions. The length of the moving portion of the structure is about 122 ft. over the leaves, while the total length, including the approach spans, is 180 ft., measured on the center line of the bridge. The length c. to c. of trunnions is 116 ft. 10 ins. There is a roadway 36 ft. in width between the wheel guards, with a 12-ft. sidewalk on each side; the two main girders are 38 ft. c. to c., and extend 3 ft. 9 ins. above the roadway, so that pedestrians cannot cross the roadway. Special attention is called to the width of sidewalk provided by the City Engineer, which is considerably greater than that usually provided and prevents unpleasant crowding of the heavy traffic. A double track street railway is laid across the bridge. Fig. 2 shows an elevation of the structure from the north side (with a half plan), while Figs. 3 and 4 are views showing the bridge open and closed.

SUBSTRUCTURE.—The substructure consists of four concrete piers, reinforced by steel members, the two piers on each side being built close against the old abutment masonry which forms the abutments of the new approach or fixed spans. A section of one of the piers is shown in Fig. 2, while a plan is shown in Fig. 5. The foundations are of piles not less than 24 ins. c. to c., driven through the bed of the river to a hardpan stratum at a depth of about 55 ft. below city datum (or mean water level), and the heads of the piles are embedded in the base of the concrete. The piers are 16 × 32 ft. on top, and each has a well to receive the counterweighted heel of one of the main girders. The forms consisted of Wakefield triple-lap sheet piling driven to 30 ft. below water line; and this has been left in place to serve as a mechanical protection to the concrete. The concrete was composed of 1 part Portland cement, 3 parts sand, and 5 parts broken stone, all measured by bulk. This is reinforced by horizontal sheets of expanded metal near the top, and by eight horizontal angle irons ($\frac{1}{4} \times 2\frac{1}{2} \times 2\frac{1}{2}$ ins.) bent to a horseshoe shape and running round the sides and outer end, as shown in Fig. 5. Besides these, pieces of $1\frac{5}{8}$-in. wire cable extend across the pier about 9 ins. from the face of the well. The waling pieces outside the sheet piling are anchored to the concrete by 1-in. bolts. In spite of careful ramming of the concrete leaks developed in the wells, at some of which the concrete was cut out and the leaks sealed with mortar. It is expected, however, that eventually the present slight leakage will stop. Hand-pumps are used for draining the wells at present, but it is proposed to install an electric pump on each side.

On each side of the well are the supports for the trunnion bearings, consisting of four steel channels (with cover plates) resting on five 12-in. I-beams embedded in the base of the pier. At the rear end of each pier are two 15-in. channels which anchor the fixed cross girder against which the heels of the swinging girders take a bearing when the bridge is closed. These uprights are in turn anchored by 12-in. I-beams and 15-in. channels embedded in the concrete, as shown in Fig. 2.

SUPERSTRUCTURE.—The superstructure of the moving part of the bridge consists of two half-through plate girders, connected by floor beams, between which are the stringers. The sidewalks are carried by lattice cantilever girders riveted to the main girders. The live load assumed was as follows: For the sidewalks and for the roadway outside of the cars mentioned below, a uniformly distributed load of 100 lbs. per sq. ft.; for the roadway, two 55,000-lb. motor cars, 42 × 8 ft., mounted on two trucks of 6-ft. wheelbase, trucks 17¾ ft. c. to c.; one car on each track moving in opposite directions, the tracks being of standard gage, 9½ ft. c. to c., and placed in the middle of the roadway. The live load for trusses was taken as the total live load for both roadway and sidewalks. The wind pressure assumed was as follows: For bracing, a lateral force (considered as a moving load) of 400 lbs. per lin. ft., acting at the floor level; for the trusses or girders, 30 lbs. per sq. ft. of exposed area when the bridge is open. The movable parts are considered as cantilevers, no part of the load being figured as transmitted from one leaf to the other through the locks.

One of the main girders is shown in Fig. 6. It is 79 ft. 1¾ ins. long, the main arm being 58 ft. 4 ins. and the heel 20 ft. 9¾ ins. long. The angle brackets shown on the heel are for the attachment of the counterweight blocks. The depth of the girder is 7 ft. 7 ins. at the outer end, and 15 ft. at the trunnion; it is composed of ⅝-in. web plates with four flange angles 9-16 × 8 × 8 ins., and cover plates 18 ins. wide. Most of the stiffeners are crimped, but others are straight, with filler plates underneath. The rivets are ⅞-in. diameter, the holes being punched small and reamed to 15-16-in. diameter. A 21-in. hole is bored for the trunnion pin, and its edges are rounded off with a file. A shelf angle supports the ends of the floor planks, and the lateral bracing is attached to the webs of the girders and floor beams. The segmental operating rack is a steel casting with spider bolted against the web of the girder, and in order to secure a rigid attachment, the bottom chord of the girder is curved to fit the rack and has an extra wide cover plate extending far enough on the rack side of the girder to be bolted directly to the inside face of the rack casting.

FIG. 4. VIEW OF BASCULE BRIDGE, OPEN.

The floor beams are plate girders of varying depth, averaging 3 ft. 6 ins., with angle brackets carrying 13 lines of 9-in. I-beam stringers, and a steel box wheel guard, as shown on the cross section, Fig. 7. In line with the floor beams are the cantilever beams for the sidewalks. The center of the roadway has two street railway tracks, 9 ft. 0 ins. c. to c., laid with 7-in. grooved girder rails which are bolted directly to the I-beam stringer. The floor of the roadway of the movable

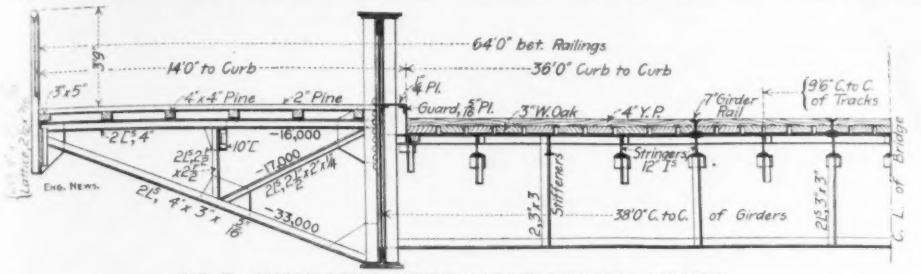


FIG. 7. HALF CROSS-SECTION OF GRAND AVE. BRIDGE.

part consists of two layers of planking; the lower course is of 4-in. yellow pine, laid diagonally with 1-in. joints, and fastened to the stringers by hook spikes driven from below; the upper layer is of 3-in. white oak laid transversely and secured by 40-penny nails. The sidewalks have 4 × 4-in. pine stringers carrying 2-in. white pine planks, 6 ins. wide, laid transversely, and with ¼-in. joints. The girder rails are cut so that those on one leaf project far enough to rest on the end floor beam of the other leaf when the bridge is closed. The trolley wires are carried by ornamental arches sprung between steel columns bolted to the top chords of the main girders.

APPROACHES.—The approach span consists of lattice deck girders 5 ft. 6¼ ins. deep, connected by heavy transverse plate girders 4 ft. 4 ins. deep. When the bridge is closed, the heels of the moving girders come to a bearing against the rear cross girders of the approach, which are therefore securely anchored to the piers, as already explained. The roadway has 12-in. I-beam stringers carrying a deck of 5-16-in. steel buckle plates (laid with the camber upward). These are covered with concrete with a minimum thickness of 2 ins., upon which is a 3-in. asphalt paving. The height from top of stringer to top of pavement is 8¾ ins. The street railway rails are laid directly upon the I-beams, as on the moving parts of the bridge. The sidewalk has 10-in. I-beams carrying a deck of steel buckle plates (laid

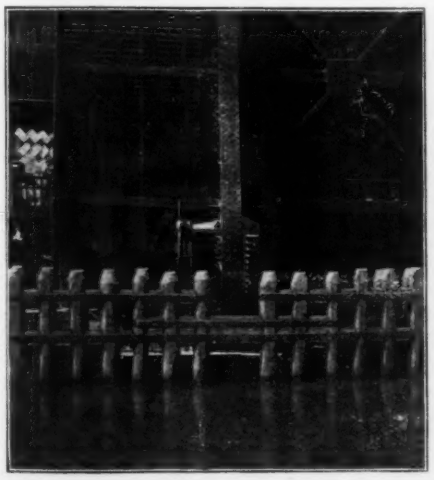


Fig. 9. View of Trunnion Shaft and Rack.

with the camber downward); these are covered with concrete made 2 ins. thick, and a 1-in. finishing course of concrete made with crushed granite. The height from top of stringer to top of pavement is 6 5-16 ins.

OPERATING MECHANISM.—Each leaf weighs about 360 tons, and is pivoted upon two 20-in. steel trunnion shafts 8 ft. long, or 6 ft. 8 ins. c. to c. of bearings, secured to the girders and having journals which revolve in bearings carried by the upright members embedded in the piers. Each girder also has bolted to it a cast-steel spider carrying the rack segment, which is concentric with the trunnion. The operating mechanism is shown in Fig. 8, where A A are the trunnions, and B B the segmental racks. A 50-HP. electric motor, C, drives the transverse shaft, D, on each end of which is a pinion, E; the pinion drives a gear wheel, F, on a short shaft, which also carries the pinion, G, gearing with the rack, B. Fig. 9 shows the position of the rack and trunnion. In ordinary service it takes about 30 seconds to fully open or close the bridge. Each half of the moving span has its own motor and mechanism, and is operated independently of the other half; four bridge tenders are employed, two for each side. A hand gear is provided in case of emergency, by which the bridge can be opened or closed in about 25 or 30 minutes. In a test made on April 7 by Mr. B. W. Perrigo, Assistant City Engineer, the bridge was opened in 26 seconds, and closed in the same length of time; it required 15.64 electrical HP. to open it and 14.40 HP. to close it. There was a fresh breeze blowing from the west at the time this test was made, which accounts for the difference in power required for opening and closing.

No gates have been provided by the city, so that two policemen are required, one at each end, to prevent people from starting to run across when the warning gong sounds. A better arrangement would be to provide suitable gates, operated by the bridge tenders. The trolley wires on each half of the bridge are independent of those on the streets, and as the length is shortened when the movable leaf rises, the wires are led around horizontal pulleys in the end arch which supports the wire, and then over vertical pulleys in the posts of these arches, the ends of the wires being attached to the counterbalance weights by spiral springs which take up any shock.

LOCKS AND BUFFERS.—The center locks consist of two wedges moving laterally across the end of the east leaf, and engaging with holes in plates on the two leaves. This is shown in plan in Fig. 10. The lock rod from the cabin, A, operates a lever, B, which is connected by a link to the toggle bars, C and D. The bar, C, has a fixed pivot, while the bar, D, is connected to the sliding transverse rod, E, of 1¼-in. gas pipe. Two short pieces of pipe, F F, are attached to this by riveted plates, and the ends of these carry the locking wedges, G G. The main purpose of these locks is to ensure the bridge being properly closed, and also to check the vibration, although the structure is very rigid when closed and left unlocked. The heel locks are upright pivoted wooden struts or posts with wedge-shaped caps which engage with shoes on the bottom chord of the heel of the swinging girder, and wedge the heel up against the end floor beam or cross girder of the approach. These locks are also operated by toggles. In Fig. 11, the oak strut is shown at A, and this is pivoted to the shoe, B, on the pier, while the top is fitted with the iron cap, C. The strut is operated by the double toggle bars, D and E; the throw of the toggle is 9½ ins., giving the top of the strut a travel or throw of 6 ins. The shoe, F, is attached to the heel of the swinging girder.

Two air buffers are attached to each leaf. The end cross girder of the approach carries two inverted cylinders, 12 ins. diameter and 16 ins. long inside, the cylinders being open at the bottom and fitted with a regulating valve at the top. In each cylinder is a piston or plunger, without packing, and turned with the face slightly convex, so that it will not jam in the cylinder. The piston rods are attached to the heel of the swinging girder. As the bridge opens, the plungers are drawn down and the valves admit air freely to the cylinders. As the bridge closes the plungers are moved upward, forcing the air out through an exhaust valve, the area of which may be varied to give the desired resistance to the motion of the bridge.

ENGINEERS AND CONTRACTORS.—The original design was made by the Wisconsin Bridge & Iron Co., of Milwaukee, Wis., and the contract for the entire work, including substructure, superstructure and operating mechanism, etc., was let to this firm. Mr. Charles J. Poetsch, M. Am.

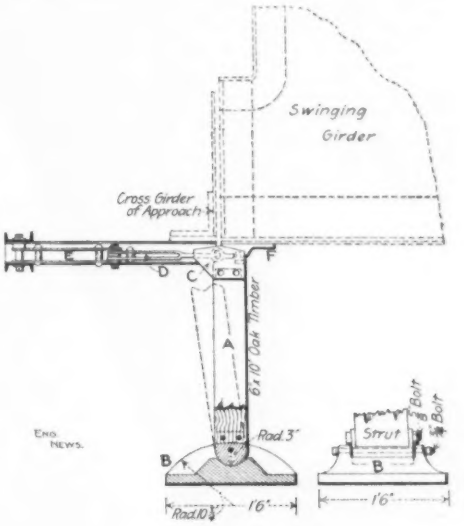


Fig. 11. Heel Lock.

Soc. C. E., City Engineer, and Mr. B. W. Perrigo, Assistant City Engineer, exercised general supervision over the work of construction. The bridge was opened for traffic on March 10, 1902, and has been in regular use since that time, with general satisfaction to all concerned. For plans and information we are indebted to the engineers and contractors.

ANNUAL CONVENTION OF THE AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

The 35th annual convention of the association was held at Saratoga, N. Y., June 23-25, 1902, and its work was divided into three sessions. The attendance was large, the discussions were unusually active and several of the papers and committee reports were of great excellence. The wisdom of the recent practice of the association in introducing a number of individual papers in place of the time-honored "committee reports," which formerly composed the entire program, was particularly evident. With one exception none of the committee reports gave so much good information or gave it in such acceptable form as did either of the three individual papers.

OPENING SESSION.

The first session was opened by prayer and by an address of welcome. President A. M. Waitt (N. Y. C. & H. R.) then delivered the customary annual address, introducing the formal work of the convention. The following are some of the features of railway motive-power practice and of convention work touched upon by President Waitt:

Statistics compiled for the year 1901 showed the total output of the eight principal locomotive building plants of this country as 3,384. This was the largest output on record, and is 7 3-10% more than in 1900. For the year ending June 1, 1902, the record of locomotive building has exceeded even the year 1901. The reports of five locomotive manufacturing companies indicate an output of 3,638, which is a total result beyond what has ever before been reached. Of these locomotives about 540 were for passenger service, 2,380 for freight service, and the balance for switching and miscellaneous uses; 80% were for use of bituminous coal; 10% for anthracite, and the balance, 10%, for oil or other fuels. Of the bituminous coal-burning standard-gage engines, about 50% were constructed with so-called wide fireboxes, extending beyond the outside of frames. During the past year about 30% of the total of passenger and freight engines built by the two largest locomotive manufacturing companies were of the compound type. The heaviest engine built during the past year weighed, not including the tender, 267,800 lbs., 237,800 lbs. of which were on the driving wheels. This was a locomotive of the decapod type, built for heavy service on the Atchison, Topeka & Santa Fe Ry.

The past five years have shown a wonderful development

in the main features of locomotive design and construction. No longer ago than 1897, passenger engines, with 2,200 ft. of heating surface, and freight engines with 2,900 ft., were spoken of as marvels of progress, and comment was made at that time of the fact that boiler pressures were being raised to above 150 lbs., and might possibly reach 180 lbs. on simple locomotives. The past year engines have been constructed for passenger service with over 3,500 ft. of heating surface, and freight engines with 5,300 ft. Most of the simple engines constructed carry 200 lbs. pressure, and some have been designed for 225 lbs. At the present time it seems to be a conceded fact that with 200 lbs. pressure the economical limit for simple engines has been reached, and that for higher pressure the compounding feature is necessary for economy in fuel consumption.

During the past two years the limitations of the two-cylinder compound engine have been reached and passed. The required dimensions for the low-pressure cylinders for two-cylinder type on the heavy engines of recent construction exceed the possible clearance limits for side tracks and switch stands, and the space between the necessary location of the center of cylinders and top of rail. In the present state of the art two alternatives seem to be presented, namely, the tandem or the four-cylinder compounds, both of which types have enthusiastic adherents and ardent opponents.

The tendency in locomotive design at present is toward a greatly reduced ratio of the grate surface and heating surface to the weight on drivers for engines burning bituminous coal, and it would appear, from the satisfactory results obtained from locomotives of recent design, that the former standards of good practice recommended by this association must be materially revised. It is an uncontroverted fact that greater attention is now being given the careful designing and proper proportioning of locomotives than ever before, and during the past three years the American locomotive has taken long strides ahead as a steam producer and speed maker.

In past years failures to make steam in sufficient quantities to reliably handle heavy passenger trains at high speeds have been rather frequent. This condition has developed the fact that there has been some error in the basis of design of locomotives for heavy or fast service. A little examination of the relation between the heating surface and the work expected from the locomotive will readily indicate the necessity for very different ratios than have been used in past years. It is a conceded fact that the weight on the driving wheels gives the limit to the power that can be exerted by a locomotive in handling a train. It is a known fact that engines designed ten years ago fail for lack of steam when assigned to haul at fast speed trains which they are abundantly able to start. It is known that locomotives designed during the past two years have overcome this difficulty, and make an abundance of steam, so that even with coal poorer in quality than ordinary, and with head winds, and an extra car or two, little difficulty is experienced in producing plenty of steam, and maintaining a fairly uniform pressure.

Taking the weight on the drivers as an indicator of the power expected from the locomotive, and assuming a proper proportioning of the cylinder and diameter of drivers for the work to be performed, we must naturally look to the source of steam production, which is the boiler. The amount of steam produced of course depends upon the coal consumed (either economically, or otherwise), and the evaporative efficiency of the boiler. Assuming a boiler of reasonably good design, the evaporative efficiency will be closely proportionate to the amount of effective heating surface provided to conduct the heat from the incandescent fire and hot gases to the water. An analysis of the vital proportions of engines that were considered marvels in their day, ten years ago, shows the ratio of heating surface in square feet to the weight on drivers in pounds as about 1 to 45, for passenger service. The once-famous 360 of the World's Fair period, had the ratio of 1 to 43.5. Engines built with the same weight on drivers for heavy or fast passenger service during the past two years have this ratio 1 to 30.5. Though both are capable of starting trains of corresponding weight, the 1893 class fails in the long run, consumes more coal per unit of work performed, and as a consequence has been consigned to services without either honor or good record. The 1901 class, with the 1 to 30 ratio, and same driving-wheel weight, does more work with less fuel, and with rare failures, and is naturally the idol of the hour. As a suggestion worthy of consideration, and the result of no small amount of observation and computation, let me recommend that in new locomotives designed for the best results under present conditions, that, for passenger service, engines burning bituminous coal should have a ratio of heating surface to weight on drivers of not more than 1 to 30. Some of the best working locomotives now in service have this ratio as low as 1 to 27. For heavy freight service, where the speed is going over a division of from 100 to 150 miles averages from 15 to 20 miles per hour, the ratio should not exceed 1 to 50. For switching service, where demands for steam are less continuous, a ratio of 1 to 75 will produce excellent results.

For some years past many of the railroad companies have been giving considerable attention to the tonnage rating of engines, until it had, for a time, become almost a fad, and was overdone. It frequently happens, in reform movements, that they are carried to extremes. In the excess of zeal to load engines up to their full-rated capacity the factor of average speed and resultant time in getting trains over the road was many times lost sight of, and engines were loaded to a point where they could only just drag the train slowly over the line, resulting in frequent stalling, breaking in two, and greatly increased wear and tear on both power and equipment. Better judgment has shown that slightly lighter loading has resulted in an increased gross engine ton mileage, more satisfactory time record in delivery of freight, greater contentment of enginemen and trainmen, and much less expense for maintenance of engines and for repairs of cars.

As has been frequently stated, the cost of coal consumption is the largest single item of expense that the motive power department has to deal with. In order to handle this question to the best advantage, it is necessary to make a careful study of the production and treatment of the coal in detail from the mine to the tender. On many large systems the work of a man, as a specialist, devoting his time to a study of the quality of coal and its handling, would, without doubt, effect a saving of from 5 to 10%.

It is a known fact that the size of locomotives of recent design is such that the limit has almost been reached for the capacity of a single fireman to properly fire the engines. If any further increase in the size of the firebox is contemplated, it may be necessary to install an automatic method of stoking. In many of the engines put in service during the last three years, an automatic stoker would, undoubtedly, be the means of considerable economies in the burning of coal.

A great deal has been said and written in regard to smokeless burning of bituminous coal, and many devices have been presented with that end in view, but none of them, in past years, seems to have met with success. Happily this condition no longer exists, as experiments during the past year have clearly and fully demonstrated that there are one or two practicable devices in actual operation by means of which the poorest grades of bituminous coal can be burned with absolute freedom from black smoke, and with only an occasional trace of light brown smoke, regardless of whether the engine is working steam or is shut off. On the New York Central & Hudson River R. R. a device of this kind has been in successful operation on one locomotive for about ten months, and since Jan. 1 it has been applied to 10 or 12 additional engines, with such success that it has been specified on new equipment. The saving in coal, with the smoke consumer, is an important feature in its favor. Within a few months past quite a number of roads have had one or more engines equipped with the device referred to, and I am told that gratifying results are realized in every instance. Reports made by road foremen of engines in charge of some of the engines on the New York Central indicate a saving of 15 to 20% in service on a division with a 148-mile run.

The report of the Secretary showed the membership of the association to be 712, and the Treasurer's report showed a balance of $2,700 in the treasury. It was voted to make the annual dues $5 for each member for the next year. After some further routine business the convention began the work of receiving and discussing the special committee reports and papers:

TON-MILE STATISTICS.—This report was presented by Mr. C. H. Quereau (N. Y. C. & H. R.) and was in substance an argument in favor of the ton-mile basis for motive power statistics, and of certain methods of comparing, separating and computing ton mileage which are indicated in the following concluding resolutions:

Resolved, That it is the sense of this association that conclusions based on a comparison of the statistics of one railroad with another may easily prove incorrect, should be given less weight than they usually are, are just only when the accompanying conditions are fairly well known and their influence can be determined with some degree of accuracy; that a comparison of the statistics of a division or a system with those of the same territory for a previous corresponding period very largely eliminates these uncertainties and makes conclusions based on such a comparison much more reliable.

Resolved, That it is the sense of this association that the ton mileage of the locomotive and caboose is a just credit to the motive power department for statistical purposes.

Resolved, That the ton-mile is the best practical basis now available for motive power and operating statistics by which to judge the efficiency of locomotive and train service.

Resolved, That actual tonnage should be used in computing ton-mile statistics for comparison with those of other roads, but for comparison with the previous records of the same system or division the use of adjusted tonnage is advisable.

Resolved, That the statistics of passenger, freight, work train and switching services should be on the ton-mile basis, each service in a separate group, and passenger and freight service to be each further grouped under Through and Local.

Resolved, That the statistics of branch lines and main lines should be kept separately.

Resolved, That the credit of ton mileage for locomotives in switching service should be proportional to their tractive power.

Resolved, That the ton mileage of trains using more than one locomotive should be divided among the locomotives attached to these trains in proportion to their tractive power and for the distance over which the helping locomotives are used.

Resolved, That the tonnage of the locomotive should be its weight in working order, plus the light weight of the tender and half its capacity of coal and water.

The discussion which followed the reading of this report arose largely from misunderstanding of its contents. These misunderstandings being explained the resolutions were put to vote and approved.

RELATIVE COST OF RUNNING TRAINS AT SLOW AND FAST SPEEDS.—This committee report was presented by Mr. Wm. McIntosh (C. R. R. of N. J.) and was very brief. It recorded the fact that an attempt had been made to obtain information by running a high-speed and a low-speed train of identical make up between Jersey City and Somerville, N. J., and return, but that it had been impossible to maintain the conditions of the test as to relative speeds and few data of any value resulted. There was no discussion of any importance.

ELECTRIC DRIVING FOR SHOPS.—This paper by Mr. C. A. Seley, of Chicago, Ill., introduced its theme by saying:

It may be thought that electrical driving for shops has its best application in new shops, designed with special reference to movement of material, but it is of special value in old establishments that have outgrown their original plan, or those which could be enlarged or rearranged in reference to economic movement of material, provided a satisfactory solution of the power problem was offered. In many old shops, and some that are not so old, additions have been put on and line shafts unduly lengthened, an engine put in here and a boiler there. The cost of these auxiliaries is not so great, but if we look into the cost of daily maintenance, the extra attendance, the handling of fuel, when distributed to a number of points, handling of ashes, the low efficiency of small isolated plants, the general waste of supplies when drawn for a number of plants scattered here and there, and carefully analyze the cost of each of these items, it will often be found that the fuel charge is by no means the greater portion of the cost.

The paper then instanced the Roanoke, Va., shops of the Norfolk & Western R. R., as an example of an old shop very largely added to and employing auxiliary steam and power in several departments, which had been changed to use electric power from a central power house, and described the plans which had been developed in making this change. These plans were based in part upon certain general principles and reasons and in part upon special local conditions. Some of the general principles and reasons were stated by the author as follows:

In large electric installations the center of electric distribution is an important point to find and the generating plant should be placed near thereto; in shop plants this is not always the ruling factor and it may pay to use a little more copper and place the plant where other considerations are of more importance.

The direct-current system of electric transmission of power and lighting was adopted, using two-wire, 220-volt current for motors and three-wire system for lights. This was determined upon after visiting a large number of plants. Direct-current machinery was chosen on account of its applicability to all the classes of service required and for three principal reasons: First, for use in crane service, as being best adapted to that work. Second, by reason of the slower speeds of direct-current motors, they are more readily directly belted to line shafts and machines without the use of intermediate countershafting. Third, alternating-current motors are very enticing on account of their simplicity and ease of repair, and I have no doubt that their makers and users have very convincing arguments for their adoption and use; they are, however, far more expensive per horse-power than direct-current motors. Great care has to be taken in wiring for the alternating-current systems to avoid trouble and losses from induction and cross currents. No trouble of this kind is experienced with the direct current if care is taken properly to proportion the wires for their load and the ordinary precautions in regard to insulation are followed. The alternating current certainly has its field in long-distance transmission, where a cheap source of power can be reached and by high voltage be economically transmitted. In such a case the final voltage and its mode of distribution must be determined by local conditions and with special reference to the work to be done.

The question how far individual motor driving should be considered for machines is an interesting one, but it is the belief of the writer that it is not necessary or advisable to consider anything but group driving in the average railroad shop. A machine may be added to any group without seriously overloading the motor, and as there are several groups we may add a number of machines without change of motors. The additional load would be shown at the switchboard, but by reason of the group system it would add but a small amount to any one motor. The reasoning in favor of group-driving of railway shop machinery is on this wise: One machine requiring 1 HP. may be taken as a unit; individually motor driven, this machine would take a 1-HP. motor to operate it, even if it ran but one-half the time, and average machine tools are idle or running light at least that amount for work or tool adjustment. Two or three such tools grouped would not require their full multiple of the unit power, but the full value of grouped driving will be reached (first), when the number of machines in the group will enable the use of a motor of sufficient size for a near approach to good electrical efficiency, which is not possible with small motors; and (second), when the number of machines is such that the proportion of idle time may be so distributed over them as to be practically continuous and effect a proportionate reduction in the power needed in the motor. For example, if one unit takes 1 HP. and is idle one-half the time, two such units can be driven by a 1-HP. motor, provided the machines are run alternately, but if both are operated together the motor will be subjected to 100% overload. If we taken 10 such units, however, and use a 5-HP. motor, the chances are about even that the motor will be driven to its rating, and they are infinitely small as to its ever getting 100% overload. There is no argument against individual motor driving in case the machines to be driven are large enough or if their isolation is necessary to facilitate movement of material, but we are considering average railway shop machinery, and in most cases, old machinery already group-driven from shafting.

The extremist in electric driving does not like to use shafting, but as against an almost 100% increase of total motor capacity required, the low electrical efficiency of small motors and also the high cost per horse-power for small motors as compared with those of moderate size and power, a reasonable length of shafting will in the end prove the best investment for our class of work.

The above described motors are in all cases to be directly belted to line shafting. The writer has seen motors directly attached on the end of line shafting, as at the General Electric Co.'s shops at Schenectady, N. Y. At another shop back-geared motors were used directly attached, but the gearing was very noisy and neither of these plans employ strictly standard motors. At the Baldwin Locomotive Works, where both individual and grouped driving are very extensively used, belts are used to the greatest possible extent and in many cases with such short belt centers as to make it surprising that good results can be obtained. It was explained that this method was very satisfactory and that after a belt was taken up a few times, in most cases it would run thereafter almost indefinitely, and if it did fail, its replacement was much easier, cheaper and speedier than to repair broken gearing. On the other hand, many shops employ gear connections between their motors and machines, especially the modern heavy machinery, much of which is now built to be directly driven. Where the gearing can be covered and protected it may do very well, but wear is inevitable and gear breakages are expensive and at times exceedingly inconvenient. There is a very desirable flexibility in a belt connection and if there should be a failure of the motor an extra one can be readily installed if standard types are employed. Some of the electrical companies have developed systems of multiple voltage, which, in connection with double or triple gearing, give a large range of adjustment of cutting speed of tools individually driven, enabling maximum output after proper speed has been determined by experiment. These systems involve the use of considerable gearing, additional wiring and a generating set arranged with reference to the number of the voltages desired. As the writer does not favor individual driving as a rule, multiple voltage was not considered in connection with the plant under discussion.

The discussion on this paper was opened by Mr. Geo. L. Fowler, who pointed out that in such cases as accurate comparisons had been possible between the cost of shaft driving and electric driving of machinery, there had been found to be little difference. The cost of driving the machinery was, however, a comparatively small factor in shop expenses and the economy of electric driving came in other ways. For example, he knew of a boiler

shop in which the substitution of electric driving had made the overhead space clear for installing hoisting and conveying machinery, which had reduced the cost of labor in handling material so much that the owners figured a saving of six times the extra expense of the electric drive. He thought that similar results would be obtained in any shop where much handling of material was required. Mr. R. V. Wright (P. & L. E.) stated that in the new shops of his company they had chosen individual driving, using variable-speed motors, so as to get the advantages of smaller changes of speed than tools were ordinarily geared for. Mr. T. R. Browne called attention to the use of both individual and group driving at the air brake and the electric works of the Westinghouse Co., using alternating-current type motors. He considered that the simplicity of this motor, the ease with which it was started and the amount of overload it would carry were important points in its favor.

SECOND SESSION.

The first business of the second session was the reading and discussion of the committee report on Up-to-Date Roundhouses. An abstract of this report and of the discussion which followed it will be published in a future issue.

BOILER DESIGN.—This report was presented by Mr. F. F. Gaines (L. V.), who announced that the data from which the conclusions of the report had been drawn were compiled from the locomotives illustrated in engineering papers during 1900, 1901 and 1902, up to May 1. The report gave these data in tabular and diagrammatic forms. The conclusions drawn and recommended for adoption as standard were as follows:

(1) For comparisons of heating surface, the relation between the indicated horse-power and total heating surface, the formula for I. HP. being:

$$\text{I. HP.} = \frac{P\ d^2\ S}{1630}$$

Where P = Boiler pressure.
d^2 = (Diameter of cylinder in inches)^2.
S = Stroke in inches.

(2) For comparisons of weight, the relation between the indicated horse-power and the total weight of engine.

The discussion was quite lengthy and considerable criticism was made of the conclusions. It was finally moved that the consideration of the report be closed without action.

A TYPICAL SHOP TO SERVE A ROAD OR DIVISION EQUIPPED WITH 300 LOCOMOTIVES.—This paper by Mr. L. R. Pomeroy, of the General Electric Co., presented several general plans for railway shops, including one advocated by the author. It also gave a list of tools, with approximate power ratings, for use in the application of electric motors, for a shop built according to the plans advocated; a list of equipment for the power house and heating system, and a discussion of costs, organization, compensation of labor and the education and training of apprentices. The accompanying cuts, Figs. 1 to 3, inclusive, show the general plan and several sections of the shop advocated in the paper, and the following excerpt from the paper is a description of these plans:

The plans presented show the author's idea of the typical shop designed to comply with the conditions indicated at the head of the paper. The erecting, machine and boiler shops are practically under one roof, compact and arranged to facilitate the handling of material, reducing to a minimum the distance to be traversed by both men and material. The longitudinal tracks in the erecting shop side are arranged to provide 25 ft. between centers, enabling, when necessary and desirable, the placing of engines between the tracks, thereby adding to the normal capacity of the shop; the capacity rating of the erecting shop, however, is based on the track capacity only. As noted on plan, the erecting shop is nominally 400 ft. long, with a track capacity of 24 locomotives, allowing ample space at either end of shop and for a definite passageway between the head and rear ends of all engines standing on the tracks.

The cranes in erecting shop are in two units of 60 tons each, the combined capacity, when working in unison, enabling the handling of the heaviest type of locomotive in use at the present time. As the cranes will not be utilized for lifting engines more than 10 to 15% of the time, two cranes are available for general use, when not employed in lifting and traversing engines, and both cranes are provided with rapid auxiliary hoists. The boiler shop being a continuation or extension of the erecting and machine shops, one of the erecting-shop cranes is available for use in the boiler department, when desired, while the other can be usefully employed in facilitating the erecting of engines, and yet both can be brought directly into service in either place, as the dictates of necessity or utility require. The engines enter from the right, preferably by means of the center track, are lifted off their wheels and carried to any convenient or desired location. The wheels are then taken to the storage tracks provided, adjacent to the wheel and axle department, and receive attention in due course. The machine shop side is divided into two bays; the one on the outside for the lighter tools served by light traveling air hoists locally arranged, as the tools and departments naturally determine; while in the other, nearest the erecting tracks, are grouped the heavy tools. This latter bay is provided with two cranes of ten and five tons capacity, respectively. These cranes are provided with rapid hoists and serve all the tools in this bay, traversing the full length of the building and also available in the boiler end, serving the tools of this department and running clear into the riveting tower.

The question of tracks, both standard and industrial, should be considered and provided when necessary. Steam and water pipes to be provided, running the entire length of the shop; also electric cables with numerous taps for portable lamps. While no arrangement for lighting is shown on plans, yet the scheme comprehends an adequate electric lighting system, with the necessary generator for same. Compressed air mains to run lengthwise of the shop, and branch pipes attached to each post to run down to a point near the floor are shown. Numerous storage tanks located at convenient points should be provided to insure a steady and uniform pressure.

The discussion of this paper was quite brief owing to the limited time available. The principal criticism made of the design was the installation of two 60-ton cranes, it being considered that two smaller cranes would have been more widely useful.

CLOSING SESSION.

Several committee reports were received at the closing session and with but one exception they were all rather hastily disposed of. The Committee on Standard Specifications for Locomotive Driving Axles reported progress and requested to be continued for another year with power to confer with the committee of the American Society for Testing Materials, with a view of having certain changes incorporated in the standard specifications of that society which would make those specifications acceptable to the association. The discussion was very brief and referred principally to the desirability of having separate requirements for locomotive-driving axles instead of common requirements for both driving axles and car axles. It was voted to continue the committee. The report on Standard Pipe Unions was practically the same as the one submitted to the Master Car Builders' Association last week (Eng. News, June 26), and the convention took the same action as did the Master Car Builders' convention. The technical work of the convention concluded with a paper

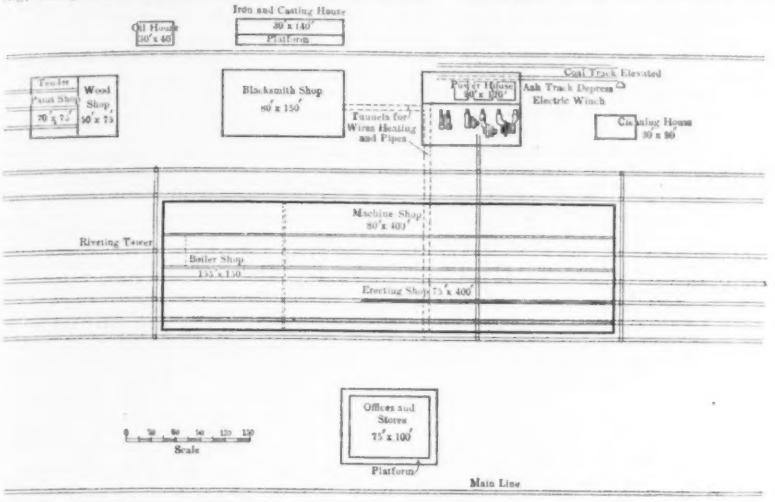

Iron and Casting House
Oil House 30' x 40'
30' x 140' Platform
Tender Paint Shop 70' x 75'
Wood Shop, 50' x 75'
Blacksmith Shop 80' x 150'
Power House 90' x 170'
Coal Track Elevated
Ash Track Depress'd
Electric Winch
Tunnels for Wires Heating and Pipes
Cleaning House 30' x 80'
Machine Shop 80' x 400'
Riveting Tower
Boiler Shop 135' x 150'
Erecting Shop 75' x 400'
Offices and Stores 75' x 100'
Platform
Scale
Main Line

FIG. 1. GENERAL PLAN OF REPAIR SHOP FOR RAILWAY, WITH 300 LOCOMOTIVES.

Wellman-Seaver-Morgan Engineering Co., Cleveland, O., Designers.

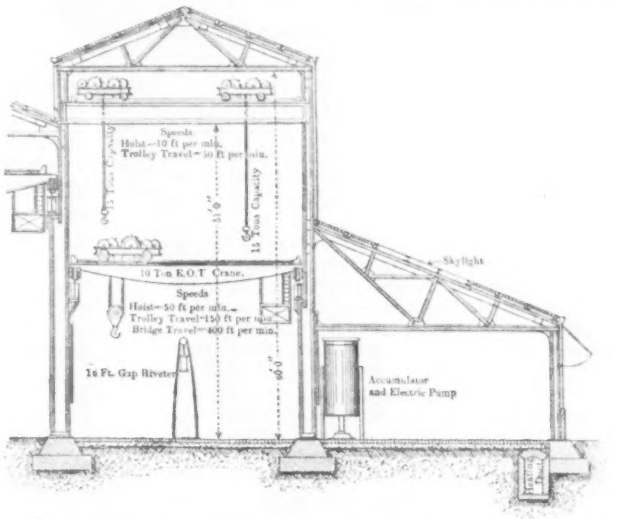


FIG. 3. TRANSVERSE SECTION OF LOCOMOTIVE REPAIR SHOP THROUGH RIVETING TOWER.

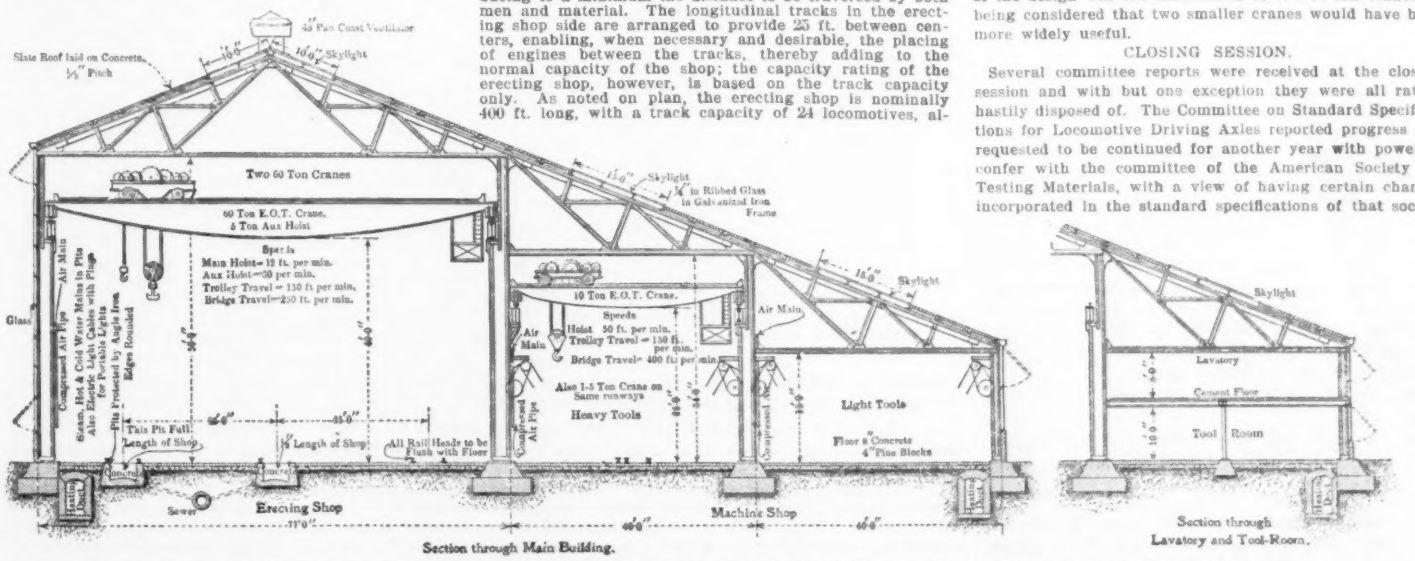

Slate Roof laid on Concrete, ¼" Pitch
Two 60 Ton Cranes
60 Ton E.O.T. Crane. 5 Ton Aux Hoist
Speeds
Main Hoist—12 ft. per min.
Aux Hoist—30 per min.
Trolley Travel = 150 ft per min.
Bridge Travel=250 ft. per min.
Glass
Compressed Air Pipe
Air Main
Steam, Hot & Cold Water Mains in Pits Also Electric Light Cables with Plugs for Portable Lights
Pits Protected by Angle Iron Edges Rounded
This Pit Full Length of Shop
½ Length of Shop
All Rail Heads to be Flush with Floor
Concrete
Sewer
Erecting Shop
77'0"
Skylight
¼" Ribbed Glass in Galvanized Iron Frame
10 Ton E.O.T. Crane.
Speeds
Hoist 50 ft. per min.
Trolley Travel = 150 ft. per min.
Bridge Travel= 400 ft. per min.
Air Main
Also 1-5 Ton Crane on Same runways
Heavy Tools
Compressed Air Pipe
Light Tools
Floor of Concrete 4" Pine Blocks
Machine Shop
46'0"
Section through Main Building.
Skylight
Lavatory
Cement Floor
Tool Room
Section through Lavatory and Tool-Room.

FIG. 2. TRANSVERSE SECTIONS OF LOCOMOTIVE REPAIR SHOP THROUGH MAIN BUILDING AND TOOL ROOM.

on "Helping Engines," by Mr. F. F. Gaines (L. V.), and a paper on "Modern Water Supply Stations for Locomotives," by Mr. F. M. Whyte (N. Y. C. & H. R.). An abstract of Mr. Whyte's paper will be given in a future issue.

ELECTION OF OFFICERS.

The following officers were elected for the ensuing year: President, G. W. West; First Vice-President, W. H. Lewis; Second Vice-President, P. H. Peck; Third Vice-President, H. F. Ball; Treasurer, Angus Sinclair; Secretary, J. W. Taylor.

SEVEN MYSTERIOUS BREAKS IN A 48-INCH PIPE LINE ON THE BOSTON WATER-WORKS.

By Frederic I. Winslow.*

The pipe line under consideration was laid in 1869-70, between Chestnut Hill and Brookline reservoirs, and was laid chiefly in cold weather. The line was 7,300 ft. long and the maximum pressure on it has never, at least until 1900, exceeded 10 lbs.

A disastrous break occurred shortly after the line was laid, and then everything was quiet until the extra head due to the pumping of all the low service water for Boston was turned on. This trebled the former head, and shortly after a break occurred, where the pipe was about fourteen feet deep. This was on Oct. 19, 1900. A joint was found blown out and a pipe cracked for almost its entire length, also a cross crack was observed. On Oct. 26 (the main in the meantime having been repaired and placed in service) a second break occurred in the third length from the first one. The third break came Nov. 10, followed by the fourth on Nov. 20.

All the breaks so far had been where the pipe was in heavy cut and it was thought advisable to take some inside measurements of the pipe. These were taken with the result of finding that the interior horizontal diameter exceeded the vertical diameter by from ⅛ to ⅝ in. Similar measurements where the depth of the pipe was not over 4 ft. showed a slightly less difference between the horizontal and vertical measurements, but always in the same direction, i. e., an excess of horizontal over vertical measurement. The fourth break had the peculiarity of having two short longitudinal breaks directly on top and on the bottom, each 8 ins. in length, and both starting at the end of the bell nearest the spigot and running towards it, the bell itself showing no crack.

The fifth break occurred Nov. 24, at a point about 2,000 ft. from the first one, and the sixth two weeks later, on the pipe length adjacent to the fifth. These two breaks occurred where the fill over the pipe was not over 4 ft.

After repairs had been made the pipe line was tested for one hour under 30 lbs. pressure and showed a leak of 3 cu. ft. per min. This leakage finally came to the surface and turned out to be in a few joints. After they had been calked the line was turned into service, and so remained for seven months. Then the pipe gave way for the seventh time, near the first break, a pipe being found to be cracked on top along the entire length, and one-half of the pipe was found to have dropped down under the half still remaining within the adjacent pipes. After a severer test than had yet been given, 50 lbs. for some days, the water was turned on and the line has not shown any weak tendencies since.

Analyses of the broken pieces resulted as follows:

Carbon*	2.19 to 3.06%	Sulphur	0.03 to 0.10%
Carbon.†	0.06 " 0.99%	Phosphorus	0.90 " 1.33%
Silicon	1.96 " 4.18%	Manganese	0.24 " 0.93%

*Graphitic. †Combined.

The tensile strength varied from 12,730 to 17,111 lbs. The transverse strength for a piece 26 × 2 × 1 in. varied from 910 to 2,090 lbs., and the deflection in this length from 0.054 to 0.553 ins. The conclusion regarding the cause of the breaks has been, that as the pipes were laid mainly in cold weather and roughly handled, the broken pipes received an initial crack before being laid, which did not come to light owing to the extremely low head carried. The effect, however, of the excess of silicon, combined carbon, sulphur and phosphorus in this pipe should not be neglected in estimating the cause of the breaks.

*Assistant Engineer City Engineer's Office, Boston, Mass.

THE EFFECT OF LONG LENGTHS OF HOSE ON FIRE STREAMS.*

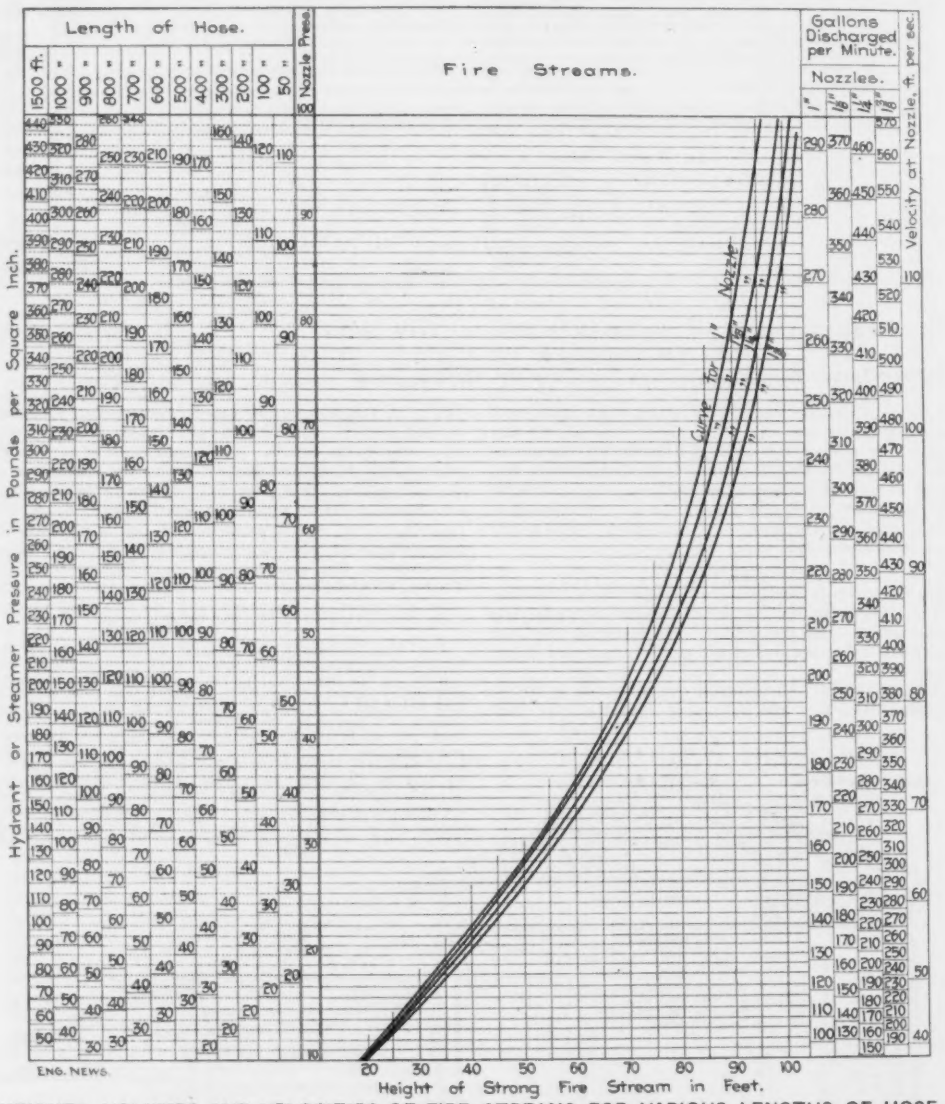
By S. A. Charles.†

We have at Lexington, Ky., the Holly or direct pressure system, throwing our fire streams direct from the hydrants without the intervention of steamers, and the works are owned by a private company. At the beginning of our contract, about 17 years ago, the supply of fire hydrants was sufficient for that time, but the increase in number of the hydrants ordered by the city has not kept pace with the growth of the city, and they have endeavored to meet the difficulty by longer and longer lines of hose, and where at the outset with hydrants 300 ft. apart from 200 to 300 ft. of hose was sufficient, it is now a common thing to use 1,000 ft. or more, on rare occasions as much as 2,000 ft. and in one instance 3,000 ft. Of course, on these long lines of hose the friction was too great to expect good streams, but the public and even the firemen themselves did not seem to realize the big difference it made, and were inclined to attribute the poor streams to a lack of pressure instead of the true cause—the excessive length of 2½-in. hose.

I was fortified with Freeman's work on "The Hydraulics of Fire Streams,"‡ and other authorities, but I found that nothing would convince them but an actual test and demonstration. Accordingly I made such a test in the presence of a number of our city officials and firemen and others. The object was to determine the effect on fire streams of long lines of hose. To ascertain this, we used two pressure gages which had been previously tested together and compared with each other and with other gages of known accuracy. One of these was attached to the fire hydrant and one at the base of a 1-in. play pipe, with varying length of hose between. The hose was good rubber-lined hose in fair condition, but not new, and probably a fair average of such hose in actual use. The hydrant pressure was maintained steadily at 100 lbs., and the pressure at base of play pipe while the stream was discharging was as follows:

Length of hose, ft.	Pressure, lbs.	Length of hose, ft.	Pressure, lbs.	Length of hose, ft.	Pressure, lbs.
50	87	400	55.7	800	38.1
100	80	500	50	900	34.8
200	69.2	600	45.5	1,000	30
300	61.2	700	41.5	1,500	22.4

These experiments were not made with the same care as Mr Freeman's experiments, as I did not have the facilities, and the principal purpose was to show that the deficient streams when they occurred were not due to lack of pressure but to excessive length of hose, yet they agreed very closely with Mr. Freeman's results as far as he went. I have used much longer lines than he did and my table covers therefore a larger field. I have compiled my results and Mr. Freeman's in the accompanying diagram, solving graphically questions as to the effect of long lines of hose on fire streams and showing conclusively the necessity for hydrants at short intervals and consequent short lines of hose.



HEIGHTS, VOLUMES AND VELOCITIES OF FIRE STREAMS FOR VARIOUS LENGTHS OF HOSE, SIZE OF NOZZLE AND POUNDS OF HYDRANT OR STEAMER AND NOZZLE PRESSURE.

(From experiments by S. A. Charles, combined with those by Mr. John R. Freeman, M. Am. Soc. C. E.)

*Abstract of a paper presented at the annual convention of the American Water-Works Association at Chicago, June 12.

†Superintendent of Water-Works, Lexington, Ky.

‡See "Trans. Am. Soc. C. E., XXI., 303-461 (Nov., 1889); also in abbreviated form, Jour. N. E. W.-W. Assoc., IV., 95-167 (March, 1890)—Ed.

If it is required to determine the height of a good strong stream thrown from a hydrant or steamer with 100 lbs. pressure at hydrant, through 200 ft. of hose, we find from the diagram or from the table given above that we will only get 69.2 lbs. at nozzle or base of play pipe and substituting this in the scale marked "Pressure at Hydrant or Engine" and following it out to the right till it intersects the curved line; vertically under the intersection we find that the stream will be 84 ft. high, and in another column it will be found to discharge 245 gallons per minute. In the same manner it may be found for any other pressure or distance or the process may be reversed to ascertain what pressure will be necessary to throw a given amount or height. In this manner we would find from the diagram that with 500 ft. of hose we would get only 50% of the pressure, and could only throw 208 gallons per minute 73 ft. high; with 1,500 ft. of hose we could only get 22.4% of the hydrant pressure and throw 140 gallons per minute 39 ft. high.